W. R. sc.

Observatory.

THE

NEWTONIAN SYSTEM

OF

PHILOSOPHY;

EXPLAINED BY FAMILIAR OBJECTS,

IN AN ENTERTAINING MANNER,

FOR THE USE OF

YOUNG LADIES AND GENTLEMEN,

By TOM TELESCOPE, A. M.

Illustrated with Copperplates and Cuts.

A NEW IMPROVED EDITION,

With many Alterations and Additions, to explain the late new Philosophical Discoveries, &c. &c.

BY A TEACHER OF PHILADELPHIA.

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INTRODUCTION:

BEING THE SUBSTANCE OF

A LETTER TO A FRIEND.

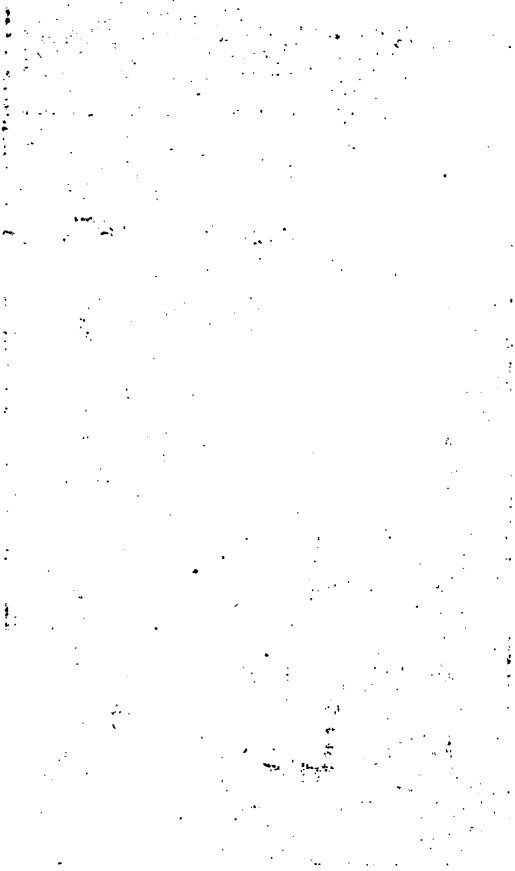
DEAR SIR,

I am desired by our worthy friend, Mr. Setstar, to give you some account of those young Gentlemen and Ladies whom you saw enter the saloon the morning you left us, and who came there on an adventure the most extraordinary and the most to be admired of any I ever knew. You may remember it was holiday-time, and these little gentry being come from school, met first at lady Twilight's to divert themselves; where they were so divided in their taste for amusements, that warm debates ensued.—One proposed Threading the Needle, another Blind Man's Buff, a third something else, &c. till at last Cards were mentioned. Master Telescope, a young gentleman of distinguished abilities, sat silent, and heard all with complacency and good temper till this diversion was proposed; but then he started from his seat, and begged they would think of some more innocent

amusement. Playing at cards for money, says he, is so nearly allied to covetousness and cheating, that I abhor it; and have often wondered, when I have seen people, seemingly of years of discretion, so far mistake themselves and abandon common sense, as to lead a young gentleman, just put into jacket and trowsers, or a little lady in a frock dress, up to a gaming table, to play and bet for shillings, crowns, and perhaps guineas, among a circle of sharpers. Parents, continued he, might almost as well teach their children to thieve as to game: for they are kindred employments, and generally terminate in the ruin of both fortune and character.—Lady Twilight, who is no friend to the modern modes of education, smiled at this young gentleman's remark, and desired him to point out some diversion himself. 'Tis impossible for me, Madam, says he, to find out an amusement suitable to the taste of all the company present, unless I was perfectly acquainted with their dispositions; but were I to chuse, I should prefer those which not only divert the mind, but improve the understanding: and such are many of the diversions at the school where I am placed. We often play at sham Orations, comical Disputes, measuring of Land and Houses, taking the Heights and Distances of Moun-

tains and Steeples, solving Problems and Paradoxes on Orreries, Globes, and Maps, and sometimes at Natural Philosophy, which I think is very entertaining, and at the same time extremely useful; for whether our knowledge is acquired by these amusements and reading little books, or by serious and elaborate study, what is obtained will be equally serviceable; nay, perhaps that which is acquired in the entertaining manner may have the advantage; for, as it is conveyed to the mind with a train of pleasing ideas, it will be the more permanent and lasting, and the easier called up by the memory to our assistance.

Mrs. Twilight was very desirous of knowing what sort of diversion could be made of Natural Philosophy: and finding her young visitors in the same disposition, she conducted them to Mr. Setstar's, that they might have the use of proper instruments. As Mr. Setstar was engaged in company, Lady Twilight, though nearly related to him, would not disturb him, but led them through the saloon into a private parlour, where our little Philosopher, at the request of her Ladyship, immediately opened the Lecture, without making idle excuses, or waiting for farther solicitations; which he knew would be ill manners.



W. R. fc.

Lecture on Matter & Motion.

LECTURE I.

OF MATTER AND MOTION.

BY Matter, my young friends, we mean the substance of all things, or that of which all bodies are composed, in whatever form or manner they may present themselves to our senses; for this top, that ivory ball, the hill before us, and all things you see, are made of matter differently formed.

As to Motion, I may save myself and you the trouble of explaining that; for every boy who can whip his top or wave a fan, knows what motion is.

Matter, or Body, is indifferent to motion or rest. As for example, when I whip my top, it runs round, or is in motion; but when I leave off whipping, the top falls down, and is at rest.

When a body is in motion, as much force is required to make it rest as was required while it was at rest, to put it in motion. Thus: Suppose a boy strikes a ball from a trap, and another stands close by to catch it, it will require as much strength or force to stop that ball, or put it in a state of rest, as the

other gave to put it in motion; allowing for the distance the two boys stand apart.

No body or part of matter can give itself either motion or rest: and therefore a body at rest will remain so for ever, unless it be put in motion by some external cause; and a body in motion will move for ever, unless some external cause stops it.

This seemed so absurd to Master Wilson, that he burst into a loud laugh. What! says he, shall any body tell me that my hoop or my top will run for ever, when I know by daily experience, that they drop of themselves, without being touched by any body? At this our little Philosopher was angry, and having requested silence; Don't expose your ignorance, Tom Wilson, for the sake of a laugh, says he; if you intend to go through my course of Philosophy, and to make yourself acquainted with the nature of things, you must prepare to hear what is more extraordinary than this. When you say that nothing touched the top or the hoop, you forget the friction or rubbing against the ground they run upon, and the resistance they meet with from the air in their course, which is very considerable, though it has escaped your notice. Somewhat too might be said on the gravity and

attraction between the top, or the hoop, and the earth; but that you are not yet able to comprehend, and therefore we shall proceed in our Lecture.

A body in motion will always move on in a straight line, unless it be turned out of it by some external cause. Thus, we see that a marble shot upon the ice, if the surface be very smooth, will continue its motion in a straight line till it is stopt by the friction of the ice and air, and the force of attraction and gravitation.

The swiftness of motion is measured by distance of place, and the length of time in which it is performed. Thus, if a cricket-ball and a fives-ball move each of them twenty yards in the same time, their motions are equally swift; but if the fives-ball moves two yards while the cricket-ball is moving one, then is the motion of the fives-ball twice as swift as the other.

But the quantity of motion is measured by the swiftness of motion as above described, and the quantity of matter moved, considered together. For instance: If the cricket-ball be equal in bulk and weight to the fives-ball, and move as swift, then it hath an equal quantity of motion. But if the cricket-ball be

twice as big and heavy as the fives-ball, and yet moves equally swift, it hath double the quantity of motion; and so in proportion.

All bodies have a natural tendency, attraction, or gravitation towards each other. Here Tom Wilson, again laughing, told the company that Philosophy was made up of nothing but hard words.—That is because you have not sense enough to enquire into, and retain the signification of words, says our Philosopher. All words, continued he, are difficult till they are explained; and when that is done, we shall find that gravity or gravitation will be as easily understood as praise or commendation; and attraction as easily as correction, which you deserve, Tom Wilson, for your impertinence.

Gravity, my young friends, is that universal disposition of matter which inclines or carries the lesser part towards the centre of the greater part, which is called weight or gravitation in the lesser body, but attraction in the greater, because it draws, as it were, the lesser body to it.—Thus, all bodies in or near the earth's surface have a tendency, or seeming inclination, to descend towards its middle part or centre; and but for this principle in nature, the earth (considering its form and

situation in the universe) could not subsist as it is, for we all suppose the earth to be nearly round (nay, we are sure it is so, for Captain Cook, and many other navigators, you know, have sailed round it); and as it is suspended in such a mighty void or space, and always in motion, what should hinder the stones, water, and other parts of matter falling from the surface, but the almighty arm of God, or this principle or universal law in nature, of attraction and gravitation, which he has established to keep the universe in order.—To illustrate and explain what I have said, let us suppose the following figure to be the earth and seas: let Tom Wilson stand at

this point of the globe of earth, where we are, and Harry Thomson at the opposite part of the earth, with his feet (as they must be) towards us: if Tom drop an orange out of his hand, it will fall down towards Harry: and if Harry drop an orange, it will fall seemingly upwards (if I may so express myself) towards Tom: and if these oranges had weight and power sufficient to displace the other particles of matter, of which the earth is composed, so as to make way to the centre, they would there unite together, and remain fixed: and they would then lose their power of gravitation, as being at the centre of gravity and unable to fall, and only retain in themselves the power of attraction.

This occasioned a general laugh; and Tom Wilson starting up, asked how Master Thompson was to stand with his feet upwards, as here represented, without having any thing to support his head? Have patience, says the little Philosopher, and I will tell you; but pray behave with good manners, Master Wilson, and don't laugh at every thing you cannot comprehend. This difficulty is solved; and all the seeming confusion which you apprehend of bodies flying off from each other is removed, by means of this at-

traction and gravitation. Ask any of the sailors who have been round the world, and they will tell you that the people on the part of the globe over against us, do not walk upon their heads, though the earth is round; and though their heels are opposite ours, they are in no more danger of falling into the mighty space beneath them, than we are of falling (or rather rising, I must call it here) up to the moon or the stars.

But besides this general law of attraction and gravitation, which affects all bodies equally and universally, there are particular bodies that attract and repel each other, as may be seen by this Magnet or Loadstone, which has the property of attracting or bringing iron to it with one end, and repelling or forcing it away with the other. My knife, says Sam Jones, which was rubbed on a loadstone some years ago, still retains the power of picking up needles and small pieces of iron.

But this, says Master Telescope, is but a small part of the virtues of the Loadstone; for until its use was discovered, sailors never ventured with their ships out of sight of land. You certainly joke Sir, says Harry Thompson, for it is impossible that a piece of iron like that can be of any service in navigating

those large ships I saw some time ago. I am sorry, replies our Philosopher, that you, like most ignorant people, should think all things which you do not know the cause of impossible; but I will soon prove to you, that it is very simple. They first procure a piece of steel, made something like a needle, but flat, about four inches long: this they rub with the Loadstone, and then balance it exactly on two points or pivets, so that it may turn round freely. One of the ends of the needle thus balanced, will always point towards the north. This needle, when put in a box, is called the mariner's compass. Thus the sailors can steer to any part of the world; which they could not do without the help of this piece of iron.

When bodies are so attracted by each other as to be united or brought into close contact, they then adhere or cohere together, so as not to be easily separated: and this is called in Philosophy, the Power of Cohesion, and is undoubtedly that principle which binds large bodies together; for all large bodies are made up of atoms or particles inconceiveably small. And this cohesion will be always proportioned to the number of particles or quantity of the surface of bodies that come into contact, or

touch each other; for those bodies which are of a spherical form will not adhere so strongly as those that are flat or square, because they can only touch each other at a certain point; and this is the reason why the particles of water and quicksilver, which are globular or round, are so easily separated with a touch, while those of metals and some other bodies, are not to be parted but with great force. To give a familiar instance of this cohesion of matter, our Philosopher took two leaden balls, and filing a part off each, so that the two flat parts might come into close contact, he gently pressed them together, and they united so firmly, that it required some considerable force to get them asunder.

The same force applied to two different bodies will always produce the same quantity of motion in each of them. To prove this, we put Master Jones into a boat, which (including his own weight) weighed ten hundred, on the Thames by the Mill-bank; and on the Lambeth side, just opposite, we placed another boat of one hundred weight, with a rope tied to it. This rope Master Jones pulled in the other boat; and we observed, that as the boats approached each other, the small boat moved ten feet for every foot the other moved:

which proves what I have before observed as to the quantity of motion.

Attraction is the stronger the nearer the attracting bodies are to each other; and in different distances of the same bodies it decreases as the squares of the distances between the centres of those bodies increase. For if two bodies at a given distance attract each other with a certain force, at half the distance they will attract each other with four times that force.

LECTURE II.

OF THE UNIVERSE, AND PARTICULARLY OF THE SOLAR SYSTEM.

THE last Lecture was read at Mr. Setstar's, who was so well pleased at these young gentlemen meeting thus to improve themselves, that he ordered them to be elegantly treated with tarts, sweetmeats, syllabubs, and such other dainties as he thought were most proper for youth: his Lady did them the honour of her company, and was particularly pleased with the conversation of Master Telescope. As it was a moonlight night, Mrs. Setstar, after supper, led them to the top of the mansion, where there was an observatory, furnished with all the instruments necessary for astronomical and philosophical observations. When the company were seated, our Philosopher thus began his second Lecture.

Look round, my dear friends, said he; you see the earth seems to be bounded at an equal distance from us every way, and appears to meet the sky which forms this beautiful arch or concave over our heads. "The Heavens

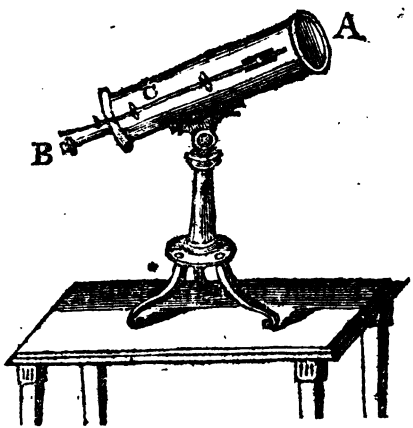
declare the glory of GOD, and the firmament sheweth his handy work," as the Psalmist beautifully expresses it. Now that distant round where we lose sight of the earth, is called the horizon; and when the sun, moon, and stars emerge from beneath and come into our sight, we say they are risen, or got above the horizon; for all this glorious canopy bespangled with lights that bedeck the Sky and illuminate the Earth, as the Sun, the Fixed Stars, the Comets, and Planets (to which last our Earth and Moon belong) have all apparent motion, as may be perceived by the naked eye; though, in fact, none move but the planets and comets; as will be proved hereafter.

But besides the stars which we see, there are others not discernible by the naked eye, some of which are fixed stars, and some are bodies moving about the most distant planets, which were invisible and unknown to us before the discovery of Telescopes.

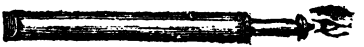
Pray hand me that Reflecting Telescope.

The young Philosopher taking it, and placing it upon the table, gave the following description:

This Telescope, from its construction, magnifies more than any other kind. It contains, within side, two metallic speculums, a large and a small one. These, with two glasses contained in the small tube, marked B, serve so to reflect and refract the rays of light issuing from the object, as to shew them under a magnified appearance. In using the Telescope, to adjust it exactly to your sight, you turn the long screw C on the side, while your eye is looking through at B, and the end A turned towards the object, till you can see the object you want to examine in the most perfect manner.



In the Refracting Telescope, which consits



of glasses only, distant objects also seem to be both magnified and brought nearer to the sight. The large end must be placed pointing toward any distant object which we wish to see more distinctly. In the other end is a tube which slides within the Telescope, and is adjusted to the proper distance by gently drawing it outwards. Now, if you look through the glass at the end of this tube, to that part of the heavens to which I have pointed it, or indeed any other part, you will perceive more stars than you saw before with your eye alone. These are fixed stars, and are called fixed, because they always keep the same distance from each other, and the same distance from the sun, which is also fixed; and were he placed at the immense distance they are at, would probably appear no bigger than one of them.—Hence some philosophers have concluded, and I think not without reason, that every fixed star is a sun that has a system of planets revolving round it, like our solar system. And if so, how immensely great, how wonderfully glorious

is the structure of this universe, which contains many thousand worlds, large as ours, suspended in æther, rolling, like the earth, round their several suns, and filled with animals, plants, and minerals, all perhaps different from ours, but all intended to magnify the Almighty Architect; "who weighed the mountains in his golden scales, who measured the ocean in the hollow of his hand, who drew out the heavens as a curtain, who maketh the clouds his chariot, and walketh on the wings of the wind."

The fervor and air of piety with which he delivered this, silenced all his companions, and gave infinite satisfaction to Mrs. Setstar. Master Wilson, who had before been very impertinent, began now to consider himself a fool in comparison to our Philosopher: and as Master Telescope had mentioned the solar system, he begged that he would explain it to him.

That I will with pleasure, replied the Philosopher, if you will be kind enough to hand me that Orrery that is in the corner of the observatory, and place it on the table; but first let me observe to you, that of these heavenly bodies some are luminous, and lend us their own light, as doth the Sun and Fixed

Stars; while others are opaque and have no light of their own to give us, but reflect to us a part of the light they receive from the sun. This is particularly the case with respect to the planets and comets of our solar system, which all give us a portion of the light they have received, and we in return reflect to them a portion of ours: for I make no doubt but those who inhabit the moon have as much of the sun's light reflected to them from our earth, as we have reflected to us from the moon.

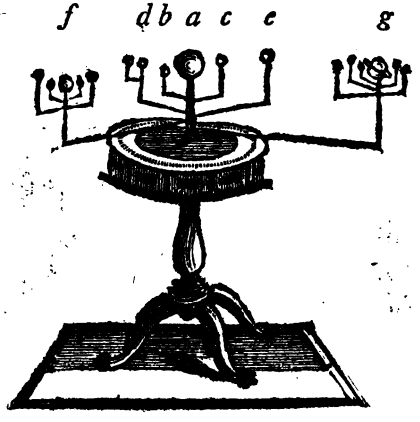
The inhabitants of the moon! says Master Lovelace, with some emotion; whither will you lead me? What! are the stories that have been told of the Man in the Moon, then, true?

I don't know what stories you have heard, replied the Philosopher; but it is no extravagant conjecture to suppose that the moon is inhabited as well as the earth; though what sort of inhabitants they are, we on earth are unable to discover. As to my part, I am lost in this boundless abyss. It appears to me that the sun, which gives life to the world, is only a beam of the glory of God, and the air which supports that life, is, as it were, the breath of his nostrils.

Do thou, O God! support me while I gaze with astonishment at thy wonderful productions; since it is not idle impertinent curiosity that leads me to this enquiry, but a fervent desire to see only the skirts of thy glory, that I may magnify thy power and thy mercy to mankind.

OF THE SOLAR SYSTEM.

NOW, by means of this Orrery, I will illustrate our Solar System; which contains the sun (marked *a*) in the centre, and the planets and comets moving about it.



But how is it then, says Tom Wilson, that we daily see the sun rise and set?

Your question, replies Master Telescope, is very natural; for it was an opinion held by the ancients some thousands of years, that the earth was the centre of the Universe, and the sun and planets revolved round it; but I think

this is easily refuted by a common occurrence in a kitchen; I mean a small bird roasting on a spit before a large fire. Would not you think it very absurd if the cook should endeavour to make the grate with a large fire move round the small bird on the spit?

Certainly I should, answers Tom Wilson; for surely it would be better for the bird to turn round before the fire, than the fire to turn round the bird.

Very well, then, says our philosopher, the sun being more than a million times larger than our earth, we have certainly reason to believe that it is the centre of our system, and the earth and other planets move round it. But you will understand this better if you look at the plate I have drawn of the sun and the planets, in their several orbits or circles, with their respective distances from the sun, and from each other; together with the orbit of a comet.

The planets, as I have already observed, are bodies that appear like stars, but are opaque; that is, they have no light in themselves, but receive it from the sun and reflect it upon us. Of these there are two kinds: the one called Primary, and the other Secondary planets.

There are seven primary planets; and these are marked on the Orrery as follows: Mercury *b*, Venus *c*, the Earth *d*, Mars *e*, Jupiter *f*, Saturn *g*, and the Georgium Sidus (which being of such recent discovery, is not represented in this Orrery.) The last of these was discovered only a few years since by Dr. Herschel, and called by him, out of respect to his present majesty king George III. the Georgium Sidus. or Georgian. All which move round the sun, as you see by my turning the winch of the Orrery; whereas the secondary planets move round other planets. —The Moon, you know (which is one of the secondary planets) moves round the Earth; four moons, or satellites, as they are frequently called, move round Jupiter; five round Saturn; and only two have yet been discovered to move round the Georgian; though we have great reason to believe there are more; but from the immense distance of that planet, we have not yet perceived them. Thus has the Almighty provided light for those regions that lie at such an immense distance from the sun.

I have here made out a table of the periods, distances, and diameters of the several planets.

	Revolves round the Sun in years, days,	Distance from the Sun in Eng. Miles.	Diameter in Eng. Miles.
Mercury	0 88	36,000,000	3261
Venus	0 224	68,000,000	7699
Earth	1 or 365	95,000,000	7920
Mars	1 & 322	145,000,000	5312
Jupiter	11—314	494,000,000	90255
Saturn	29—167	906,000,000	80012
Georgian	83—121	1812,000,000	34217

They all move round the sun from west to east; but in their progress do not describe a perfect circle, but an orbit a little inclining to an oval; the reason whereof I shall give you in a future Lecture.

The knowledge we have of comets is very imperfect; it is a general supposition that they are planetary bodies forming a part of our system, for they revolve about the sun in extremely long elliptic curves, being sometimes very near it, at others extending far beyond the sphere of the Georgian. The period in revolving about the sun, of one which appeared in 1680, is computed to be 575 years.

But let us quit these bodies, of which we know so little, and speak of our old companion the Moon, with whom we ought to be better acquainted: since she not only lights us home in the night, but lends her aid to get our ships out of the docks, and to bring in and

carry out our merchandize; for without the assistance of Lady Luna you would have no tides. But more of this hereafter.—A little more now, if you please, says Tom Wilson. What then, does the moon pour down water to occasion the tides? I am at a loss to understand you. No, replied our philosopher, the moon does not pour down water to occasion the tides; that were impossible: but she, by attracting the waters of the sea, raises them higher; and that is the reason why the tides are always governed by the moon.

The Moon's diameter is 2,160 miles; her distance from the earth is 240 thousand miles; she moves round it in the same manner as the earth does round the sun; she performs her synodical motion, as it is called, in 29 days, 12 hours, and 44 minutes, though the periodical is 27 days, 7 hours, and 43 minutes. By this motion of the moon are occasioned the eclipses of the sun and moon, and the different appearances, aspects, or phases she at different times puts on: for when the earth is so situated between the sun and the moon, that we see all her enlightened parts, it is Full Moon; when the moon is so situated between the sun and the earth, that her enlightened parts are hid or turned from us, it is New

Moon; and when her situation is such that only a portion of her enlightened part is hid from us, we see a Horned Moon, a Half Moon, or a Gibbous Moon, according to the quantity of the enlightened part we can perceive.

But I will endeavour to explain this to you more clearly, says our philosopher, taking an ivory ball suspended by a string, in his hand; we will suppose this ball to be the moon, the candle the sun, and my head the earth. When I place the ivory ball in a direct line betwixt my eye and the candle, it appears all dark, because the enlightened part is opposite the candle; but if I move the ball a little to the right, I perceive a streak of light, which is like the New Moon; if the ball is moved further it presents the appearance of a Half Moon; move it still further, until all the enlightened part is seen, it appears like a Full Moon.

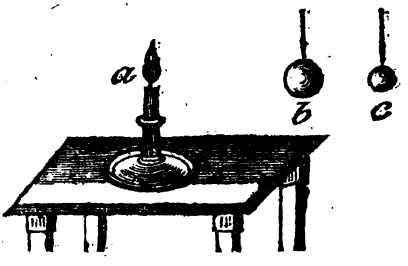
I think it is extraordinary, says Tom Wilson, that the Moon which you say is so much smaller than the Sun, should appear to our sight equally large.

That is easily explained, replied our Philosopher, for if you consider that the sun is at 400 times a greater distance from us than the

moon, your objection is answered; but this I will explain further in treating of Eclipses.

I have frequently observed, says Master Lovelace, that the moon appears much larger when just rising above the horizon, than she does afterwards; I should like to know the cause of that. I thank you for your observation, Sir, replies our Philosopher; it is occasioned by the fogs or exalations that arise from the earth, which always magnify objects seen through them; thus the moon, until she rises above these fogs, always appears larger.

The total or longest eclipse of the moon happens when the earth is directly between the sun and the moon, and prevents the light of the sun from falling upon and being reflected by the moon; as you will understand by looking at the figure I have here drawn.



We will suppose the candle *a* to be the Sun; the cricket-ball *b*, to be the Earth; and the fives-ball *c*, to be the Moon. A string being tied to each of the balls, I tie them up to the ceiling, or any other support, in a direct line from the light of the candle; the cricket-ball about eight inches from the candle, and the fives-ball about two inches from the cricket-ball. Whenever the earth and moon come in the position of these balls, a total eclipse of the moon ensues; because the light of the candle (or sun) shining on the cricket-ball (or the earth) totally obscures or eclipses the fives-ball (or the moon); but if we move the fives-ball a little higher up, or lower down, so that the light from the candle may pass by the cricket-ball, it will of course be only partially eclipsed.

An Eclipse of the Sun is occasioned by the moon's being betwixt the sun and the earth, and preventing the light of the sun from coming to that part of the earth we inhabit.

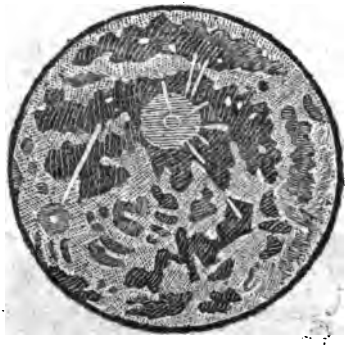
This may be explained by changing the places of the balls; for when the fives-ball is placed between the cricket-ball and the candle, it will shew a total eclipse of the sun; but if the cricket-ball is moved a small degree higher up or lower down, so that the light from the candle shines

a little upon it, it will shew only a partial eclipse.

But I should be glad to be informed, says Master Lovelace, how the sun which is so much larger than the moon, can be totally eclipsed from our sight, by the moon coming betwixt us and it?

That is what I intended to explain to you, replied Master Telescope. If you place your cricket-ball in a direct line between your eye and the sun, it will entirely hinder you from seeing it, although your ball is much smaller than the sun.

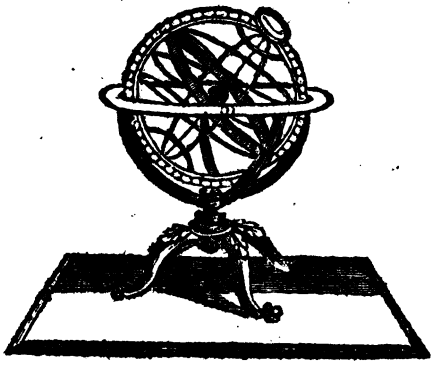
An eclipse of the sun never happens but at new moon; nor one of the moon but when she is at the full.



The Moon consits of Mountains and Vallies, not unlike our Earth, and appears very beautiful when seen through the Telescope I shewed you some time ago.

The livid spots and bright streaks of light are supposed to be the mountainous parts; and the same parts being constantly turned towards the earth, she always presents the same side to us. The dark parts were formerly imagined to be seas; but from later observation it is proved, that they are hollow places or caverns, which do not reflect the light of the sun.

The Earth, by its revolution about the sun in 365 days, 5 hours, and 49 minutes, measures out that space of time which we call a

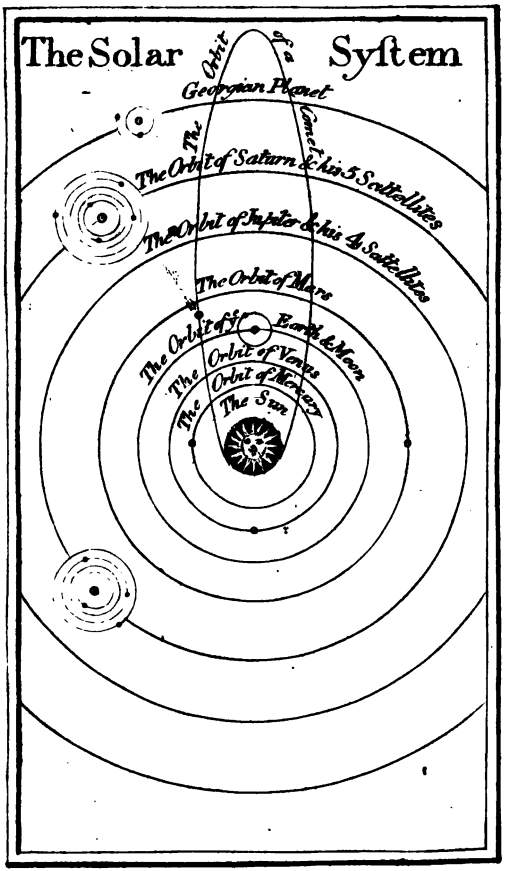


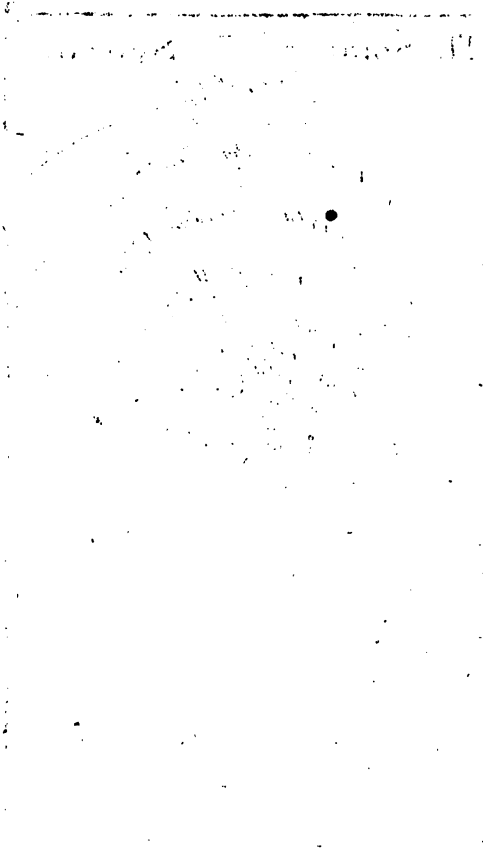
Year; and the line described by the earth in this annual revolution about the sun, is called the Ecliptic. By an inspection of this Armillary Sphere you will have a perfect idea of this and other circles necessary to be known.

The annual motion of the earth round the sun is from west to east, or, to speak more philosophically, it is according to the order of the signs of the Zodiac; which we shall hereafter explain.

But besides this annual motion or revolution about the sun in the line of the Ecliptic, the earth turns round upon its own axis in about 24 hours; so that it hath two motions at one and the same time.

Mrs. Setstar, whose curiosity had kept her there during the Lecture, desired to have this explained.—That shall be done, Madam, in a minute, says the little philosopher; and I can never have a better opportunity; for I see Mr. Galaxy coming on a visit to your Ladyship; his coach is just entering the iron gates, and will presently wheel round the circle, or rather oval, before the portico. Pray, Madam, fix your eyes on one of the wheels (which you may do as it is moon-light) and you will perceive it turn round upon its own axis, at the same time that it runs round the


The Solar System
The Orbit of a Comet
Georgian Planet
The Orbit of Saturn & his 5 Satellites
The Orbit of Jupiter & his 4 Satellites
The Orbit of Mars
The Orbit of the Earth & Moon
The Orbit of Venus
The Orbit of Mercury
The Sun



oval before the house. This double motion of the wheel very fitly represents the two motions of the earth.

By means of this Terrestrial Globe I shall

explain more interesting astronomical principles.

Your Ladyship knows perfectly that the earth, turning on its own axis, makes the difference of the day and night; you will therefore give me leave, Madam, to address my discourse to these young gentlemen and ladies, who may be ignorant of this branch of philosophy.

That the turning of the earth on its own axis, makes the difference of day and night is most certain: for in those parts of the earth which are turned toward the sun it will be day; and of course it must be night in those which are turned from it.

But the length of days and nights, and the variations of the seasons, are occasioned by the annual revolution of the earth about the sun in the Ecliptic; for, as the earth in this course keeps its axis equally inclined everywhere to the plane of the ecliptic and parallel to itself, the earth in this direction has sometimes one of its poles nearest the sun, and sometimes the other. Hence heat and cold, summer and winter, and length of days and nights. Yet notwithstanding these effects of of the sun, which gives us light and heat, his distance from us is so great, that a cannon-ball would be twenty-five years coming from thence to the earth, even if it flew with the same velocity as it does when it is first discharged from the mouth of a cannon.

Here they were all amazed; and Lady Caroline said this doctrine could not be true; for if the sun were at that immense distance, his light could not reach us every morning in the manner it does. I beg your pardon, Madam,

replied the philosopher, your Ladyship's mistake arises from your not knowing, or at least not considering the amazing velocity of light, which although coming from the sun, which is more than 95 millions of miles distance, reaches us in the space of seven minutes and a half, it must in consequence travel at the rate of about 212,000 miles in one second of time.

But if you are so surprised at the sun's distance, Madam, what think you of the fixed stars, which are so far remote from us, that a cannon-ball, flying with the same velocity as when first discharged, would be 700,000 years in coming to the earth? Yet many of these stars are seen even without the use of telescopes.

There are other things observable in our Solar System, which, if attended to, will excite our admiration: such as the dark spots which are seen on the Sun's surface, and which often change their place, number, and magnitude. Such also is the amazing Ring which encompasses the body of the planet Saturn: and such are the belts that gird the body of Jupiter:—concerning all which there are various conjectures; but conjectures in philosophy are rarely to be admitted.

LECTURE III.

OF THE AIR, ATMOSPHERE, AND METEORS.

WHAT was said by Mrs. Galaxy and Lady Caroline in favour of Master Telescope, excited Mr. Galaxy's curiosity to see him; and the next morning he came into the Observatory just as the Lecture began. The presence of so great a personage put the young gentlemen into some confusion, and several of them offered to go away; which Mr. G. observing, prevented by stepping into the next room; and Master Telescope took this opportunity to correct their folly.

Gentlemen, says he, I am amazed at your meanness and ill manners. What! because the gentleman does you the honour of a visit, will you run away from him?—There is nothing betrays a mean spirit and low education so much as this ridiculous awe and dread which some people shew in the company of their superiors: and besides, it is troublesome; for the uneasiness one person is in, communicates itself to the rest of the compa-

ny, and abridges them of a portion of their pleasure. The easier you appear in the company of the great, the more polite you will be esteemed. None but a clown hangs down his head, and hides his face; for a gentleman always looks in the face of his superior when he talks to him, and behaves with openess and freedom. I venerate Mr. Galaxy for his virtues and amiable character, as highly as any of you; and this inclines me to *wish* for his company, rather than to *avoid* it. Fortune, and what the world ridiculously calls high-birth, are merely accidental, and may often be found in persons of the most worthless description; whilst on the other hand, we sometimes find in persons of mean parentage, (as it is called) and without any of the tinsel of fortune, those amiable virtues, and that nobleness of soul, which justly claim our highest veneration and esteem.

This reproof, and these remarks had their proper effect; for they all sat down, and Mr. Galaxy having returned, accompanied by his Lady, our philosopher began his lecture on the nature and properties of the air, atmosphere, and meteors contained therein.

We have already considered the Earth as a planet, says he, and observed its diurnal and

annual motion; we are now to speak of the materials of which it is composed, and of the Atmosphere, and the Meteors that surround and attend it.

In order to explain these effectually, says Mr. Galaxy, you should, I think, Sir, begin with an account of the first principles of the four Elements, which are Fire, Air, Earth and Water, and then to shew how they affect each other, and by their mutual aid give motion, life and spirit to all things; for without fire, the water would assume a different form, and become solid ice; without water, the fire would scorch up the earth, and destroy both animals and plants; without air, the fire perhaps would be unable to execute its office; nor without air, could the water, though exhaled by the sun into clouds, be distributed over the earth for the nourishment of plants and animals. Nor is the earth inactive, but lends her aid to the other elements; for she, by reflecting the sun's beams, occasions that warmth which nourishes all things on her surface; but which would be very inconsiderable and scarcely felt, if a man was placed on the highest mountain, above the common level of the earth, and in such a situation as to be deprived of her reflection.

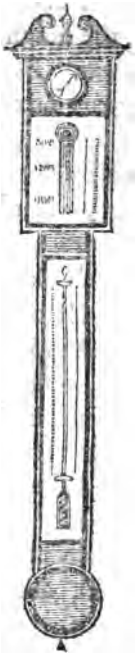
All this, Sir, I have considered, replied the Philosopher; and had thoughts of carrying it farther, and shewing how those elements pervade and are become indeed constituent parts of the same body; for Fire, Air, Earth, and Water, are to be drawn even from a dry stick of wood. That two sticks rubbed violently together will produce fire, is very well known; for coach or waggon-wheels frequently take fire when not properly clouted with iron, and supplied with grease; and if pieces of wood, seemingly dry, be put into a glass retort over a furnace, you'll obtain both air and water; and then if you burn the wood to ashes, and wash out the salts with water, as the good women do when they make lye, the remaining part will be pure earth: and thus we can at any time draw the four elements out of a stick of wood. But as these speculations are above the comprehension of some of the young gentlemen whom I have the honour to instruct, I shall defer the consideration of such minute and and absruse matters till another opportunity. Science is to be taught as we teach children the use of their legs; they are at first shewn how to stand alone; after this, they are taught to walk with safety, and then suffered to run as fast as they please:

and I beg you will be so good as to permit me to pursue this method in the course of my Lectures. Mr. Galaxy gave his assent with a nod; and our philosopher thus proceeded:

The Air is a light, thin, elastic or springy body, which may be felt, but not seen; it is fluid, and runs in a current like water (as you may perceive by opening the window;) but it cannot, like water, be congealed into ice; and the Atmosphere is that great body or shell of air which surrounds the earth, and which reaches many miles above its surface, as is known by considering the elasticity or springiness of the air and its weight together; for a column of air is of equal weight with a clumn of quicksilver of between 29 and 30 inches high. Now quicksilver being near four times heavier than water, if the Air was as heavy as water, the Atmosphere would be about fourteen times higher than the column of quicksilver, or about 34 feet; but the Air is near 1000 times lighter than water; therefore the Atmosphere must be many miles high, even at this rate of computing. And when with this you consider the elasticity of the Air, which, when the pressure of the incumbent Atmosphere is taken off, will dilate itself so as to fill more than 150 times the

space it occupied before, you will perceive that the height of the Atmosphere must be very great. For as the Air is a springy body, that part next the earth must be more dense than the upper part, as being pressed down by the air above it. Look at that hay-stack yonder, which the groom is cutting, and you'll perceive that the hay at the bottom is much closer and harder to cut than that at the top, because it has been pressed into a less space than it otherwise would have occupied, by the other hay above it; and had not the whole stack been trodden and pressed down by the men who made it, the difference would have been still more considerable.

The air, however, even near the earth, is not always in the same state. It is sometimes rarefied, and becomes lighter than at other times, as apears by the quicksilver's falling in the barometer, and the rains descending on the earth.



It may be acceptable here, says the young Philosopher, to explain the construction of that triple weather-glass that I see hanging up before me. So walking up to it, he described it in the following manner: The uppermost instrument contained in the round brass box, is called the Hygrometer, (marked *a*). It consists of a brass plate, divided into degrees both ways, right and left, from 0 to 180. To the left is engraved *Moist*, and to the right *Dry*. In the centre of the plate is fixed the beard of a wild oat, with a piece of straw glued to it, as an index. The Index is first set to 0 of the divisions, so that any change of the air which happens afterwards in the room to *Moist* or *Dry*, the beard by twisting or untwisting itself from the action of the air, will by the index point it out accordingly on the scale.

The open square part next below, is called the Barometer, (marked *b*). It consists of a glass tube about 32 inches long, closed at the top, first filled with quicksilver, and then inverted on a reservior, or leather bag below, of quicksilver. By this means the quicksilver in the tube subsides to its proper height, as acted upon by the pressure of the air, or atmosphere; for it is the dense state, or heaviness of the air, that raises the quicksilver in the barometer, and prevents the clouds from distilling through the air in rain; and, on the contrary, its lightness that admits the fall in showers, &c.

Barometers are also used to determine the heights of mountains, &c. because as we ascend, the quicksilver rises in proportion; the weight of the atmosphere which presses on it being less.

But what is the use of that screw at the bottom of the instrument? says Master Wilson. I thank you for the question, says the Philosopher; for many a young ignoramus has totally spoiled a good barometer, by foolishly playing with that screw till they forced it up, broke the bag, and let out all the quicksilver. Let it be particularly known, that this screw is only provided by the instrument-maker, to

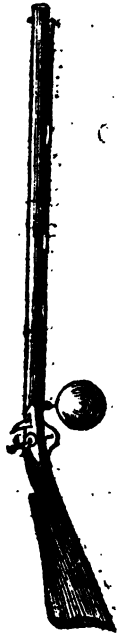
force up the quicksilver in its tube in a gentle manner, so that in conveying the instrument into the country or abroad, it is thus made quite portable, and not liable to have the tube broken by the concussion of the quicksilver against the top of the tube. The next instrument below is called the Thermometer (marked *c*). It contains a long glass tube, partly filled with quicksilver, and screwed down to a brass scale, on which are marked divisions and terms of various degrees of heat and cold, from boiling water down to freezing, found and adjusted by actual trial of the maker. The freezing point is marked 32, and the boiling water 212. This is called Fahrenheit's Scale, as being the name of the inventor. The heat of the air expands the quicksilver in the ball; and it accordingly rises in the tube; whereas, on the contrary, cold contracts the quicksilver, and it of course falls, so that at any time by mere inspection, the change of the temperature of the air is immediately shewn.

The elastic principle in the air, which renders it so capable of being rarefied and condensed, has been productive of the most wonderful effects. But before you proceed farther, says Lady Caroline, pray do me the fa-

vour, Sir, to convince me, by some experiment, that the air is endowed with this wonderful quality.—That he cannot do, replied Mr. Setstar, without the use of proper instruments.—Almost any thing will do, says the Philosopher.—Little Master's pop-gun that lies in the window, is sufficient for my purpose. Do me the honour to step this way, Lady Caroline. You see here is a pellet in the top of this tube, made of hemp or brown paper. With this piece of paper I will make another pellet, and put it into the other end. Now with the gun-stick drive it forward. There you have forced the pellet some part of the way with ease; but it will be more difficult to get it farther, because the air, being compressed and made more dense or compact, will make more resistance; and when you have pressed it so close that its force overpowers the resistance which the pellet makes at the other end, that pellet will fly off with a bounce, and be thrown by the spring of the air to a considerable distance. There, see with what force it is thrown!

This you have taken little notice of, because it is a school-boy's action, and is seen every day; for, indeed, we seldom trouble ourselves to reason about things that are so familiar;

yet on this principle, my Lady, depends the force of a cannon; for it is not the gun-powder and fire that drives out the ball with such prodigous velocity; no, that force is occasioned by the fire's suddenly rarefying the air which was contained in the chamber or breach of the cannon, and that generated by the powder itself. As a proof of this, place the same ball in the same quantity of powder in an open vessel, and when fired you will scarce see it move. But there have been guns lately invented, called Air-guns, which abundantly prove what I have advanced; for they are charged only with concentrated or condensed air.



Here is one, I perceive, hanging over my head, where you are to observe that the ball, which is previously filled by a syringe with the condensed air, is screwed under the back, and by pulling the trigger, a valve is pushed in the ball by a pin; the air rushes

from thence, through the back, into the barrel, against the bullet, and drives it to a great distance; and the air in the ball is sufficient to discharge six or seven balls, one after the other; each of which would kill a buck or a doe at a very considerable distance.

You seem all amazed, and I don't wonder at it, since you have never yet considered the extraordinary properties of this element; and it must seem strange to you that the air, which is so necessary for life, that without it we cannot breathe, should be tortured into an instrument of destruction. You will, however, be more surprised when I tell you that this is probably the cause of earthquakes; and that the noble city of Lisbon was some years ago destroyed by a sudden rarefaction of the air contained in some of the caverns of the earth, and perhaps under the sea.——Tom Wilson gave a leer of impertinence, but was ashamed to shew his folly before such good company. All the rest stared at each other without speaking a word, except Lady Caroline, who protested she could not believe what he had said about earthquakes; for, says she, I remember to have read in the news-papers, that the flames burst out of the ground. That might be, my Lady,

says the little Philosopher; for there could be no such sudden rarefaction of the air without fire. Fire therefore did contribute towards the earthquake, and fire might burn down a mountain composed of combustibles; but fire could never blow one up. No, my Lady, that effect is the sole property of the air. This dispute would, in all probability, have taken up much time; but Mr. Setstar put an end to the controversy, by declaring it was true philosophy.

In this property of being rarefied and condensed, the air differs amazingly from water, which, though composed of such small particles as not to be distinguished or seen separately with a microscope, and notwithstanding its readiness to rise or be evaporated with heat, and to be separated with a touch, cannot, when confined, be at all concentrated, or brought into a less compass.

I have already intimated that heat is the efficient cause of all fluidity, and that ice may therefore be termed the natural state of water; the utility of which to man, as well in diluting his food as in increasing his enjoyments in various modes, it would be tedious and useless minutely to describe to you; containing a quantity of air, it is the medium by which

aquatic animals respire. It is also, if not the principal, at least a considerable part of the food of Vegetables; which I will afterwards explain to you.

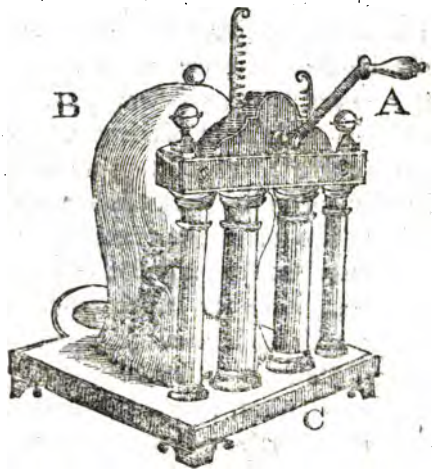
By increasing the heat water is rendered elastic and volatile; that is, is converted into vapour, the force of which, when confined is almost incredible; this force has been applied to the use of Mechanics in the Steam Engines, by which it is said, that a single drop of water, converted into vapour, is capable of raising several hundred weight. The construction of these engines is so very complicated, that it is impossible for me to explain without a model.

Air is the medium which diffuses light to the world; for if there was no atmosphere to to refract the sun's rays round the globe, it would be almost as dark in the day-time as in the night; and the sun, moon, and stars, would only be visible. It is also the medium of sounds, which are conveyed by the tremulous motion of the air, when agitated by any noise. Let me throw this peach-stone into the moat, and you will perceive circles of small waves diffuse themselves by degrees to a great distance round it. Now, as the air is fluid as well as the water, we may conclude

that sound is conveyed somewhat in this manner; though as that is nearly a thousand times lighter than water, sounds are propagated at an amazing rate: some say, after the rate of 1,142 feet in a second of time; but however that be, we may rest assured that sound is conveyed in this manner:——Only throw up the sash and halloo, and the echo will return you the sound; that is, the waves or pulses of air, which are put in motion by the noise you make, will strike against the rocks and return to you again: for echo is nothing but the reverberation of sound. And that there can be no sound conveyed without air, is proved by experiment; for a bell, struck in an exhausted receiver in an air-pump, cannot be heard; that is, it has little or no sound.

Without air there would be no merchandize; for your ships could not sail to foreign climates; and without air the birds could not fly, since they would have nothing to support them, and their wings would be useless; for we know that a feather falls with as much velocity as a guinea in an exhausted receiver of an air-pump. But above all, air is the principle which preserves life both in plants and animals; there is no breathing without air:

and you know, when our breath is stopt, we die. This is one of those truths that are called self-evident; because it is universally known, and needs no confirmation; but if demonstration be thought necessary, you may have it in a minute, by putting some living animal into an air-pump.—But, said Lady Caroline, it is cruel to torture a poor animal; and violently opposed this experiment being tried; but as the rest were for it, Mr. Setstar was willing to gratify their curiosity, and therefore told our philosopher that he might try the experiment with a rat, which they had caught in a trap; and if he survived it, give him his life for the pain they had put him to. Master Telescope, after placing the air-pump on the table, proceeded as follows:



By the help of this machine, all that I have spoken concerning the weight and elasticity of the air, is demonstrated in the most simple and elegant manner. For by working the handle (marked A) all the air that is contained within the glass receiver (marked B) is pumped out; and if any living animal is put within the receiver, all the air in its body is pumped out likewise: then, as I mentioned before, air being the principle which preserves life, the animal dies, unless fresh air be immediately admitted, which may be done by turn-

ing a screw (at C). Our philosopher then put the rat into the receiver; and when the air was nearly exhausted, it appeared in great agony, and convulsed; and more air being pumped out, it fell on its side for dead; but fresh air being immediately admitted, it rushed into its lungs, which put them in motion again, and he recovered. The manner of the animal's recovery puts me in mind, says the philosopher, of an accident which I once saw, and which I would have you all remember; for it may be of service to mankind.

Some time ago I was bathing with several of my school-fellows in a river by the road-side. Master Curtis, who was an obstinate silly boy, would dastard the rest, as he called it; that is, he would foolishly exceed them in running into dangers and difficulties; and with this view, though he could swim no more than a stone, he plunged into a part of the river, which we told him was greatly above his depth, where he rose and struggled to get out, but could not. We were all in the utmost distress, and unable to assist him, for none of us could swim. At this instant some gentlemen on horseback came up, who immediately dismounted, and got him out;

but not till he had sunk the third time.—He was brought to the shore without signs of life, and blooded without any effect; when one of the gentlemen, who, I have since heard, was a great philosopher, advised them to blow some air down his throat: this was done, and the elasticity of the air put his lungs in motion, as I imagine, for a pulsation immediately ensued; he recovered almost as soon as this animal. Now, from what I heard that gentlemen say, and from the instance before us, there is reason to believe that the lives of many might be saved, who are supposed drowned, if this method was put in practice of conveying air to the lungs; for you are to consider, that unless the lungs are in motion, there can be no circulation; and it was for want of air that their motion ceased in the water. Pray, gentlemen, let this be remembered, for it is a matter of great importance.

We are to observe, gentleman, that air which has passed through fire, or is become foul or stagnated, and has lost its spring, is unfit for respiration. It was the want of fresh air, or, in other words, the being obliged to breathe air that was foul, and had lost its spring, or elastic force, that some years ago killed so many poor Englishmen in the black hole at Calcutta, in the East Indies: and

this breathing of foul air in inflamatory, putrid, and eruptive disorders; such, for instance, as the small-pox and some fevers, has destroyed more than can be imagined. If therefore you should be seized with any of these disorders, advise the people about you to make use of their common sense, and not, because a man is ill, deprive him of that vital principle, the air, without which he could not live, even in a sate of health. Never suffer your curtains to be drawn close, or exclude the fresh air, even when you sleep.

I am greatly mistaken, says Lady Caroline, if the air we are now in has not lost its spring; for I breathe with difficulty. Was that the case, Madam, replied the little philosopher, you would not be able to breathe at all; but if your Ladyship finds the air so disposed, you should make use of the instrument that lies by you; which, by putting the air in motion, will, in part, recover its spring. What instrument, Sir? says the Lady. Your fan, Madam, returned the philosopher. Every fan is a philosophical instrument, and was originally contrived, we may suppose, for the purpose above-mentioned.

A bird dying in an air-pump will be in some measure recovered by the convulsive flutter-

ıg of its own wings; because that motion al-
:rs the state of the air remaining in the
:ceiver, and for a time renders it fit for res-
iration.

Motion is the only preservative for air and
/ater; both of which become unwholesome
: kept long in a state of rest; and both may
e recovered and made salutary by being
gain put in motion.

If foul and stagnated air has such dire ef-
:cts, how much are we obliged to the learn-
d and ingenious Dr. Hales for discovering
ıe Ventilator: an instrument which, in a lit-
le time, discharges the foul air from ships,
risons, and other close places, and supplies
ıem with that which is fresh!

The researches of our modern philoso-
hers, says our Lecturer, have been the means
f many new discoveries in regard to air.
'hey now produce and prove the existence
many different sorts of air: such as our
)mmon air, inflammable air, nitrous air,
ephitic air, more technically denominated
them gasses, or elastic fluids. But it
)uld be difficult to give you clear ideas up-
this subject, without you had some pre-
)us knowledge of Chemistry. I must there-

fore beg leave to dispense with the account of these now, and only to advise my hearers to a study of Chemistry, as now improved, as a science that will afford them much pleasure, and information in Nature's wonderful operations

When you mentioned inflammable air, says Master Wilson, I thought you would have mentioned the Balloon; which, of all wonders, I think the greatest. I protest it perplexes me to account how in nature it is possible for any large hollow substance, even although filled with air, to float in the atmosphere, particularly when weighed down with a boat and two men in it, as represented in this picture hung near me; which records the memorable event of Mr. Blanchard and Dr. Jefferies crossing the English Channel from Dover to France.

I am surprised at so simple a question, says our philosopher. Why, surely, you never considered the reason of those balls that I have seen you make by soap and water beat to a lather, and blown out of the bowl of a tobacco-pipe. The air, by which they are blown, issuing from your lungs, is specifically lighter than the common air, even when contained in that thin watery globe. Now, inflammable air is about ten times lighter than common air; so that a large hollow silk balloon, filled with inflammable air, although loaded with a boat, two men, and sundries, is lighter in its bulk

than common air; and consequently, when released from its cords that fasten it to the ground, it rises majestically, and soars along, in and above the clouds, according to the direction of the wind.

We are now to speak of the Wind, which is only a stream or current of air, as a river is of water, and is occasioned by heat, eruptions of vapours, condensations, rarefactions, the pressure of clouds, the fall of rains, or some other accident that disturbs the equilibrium of the air: for Nature abhors a vacuum, and for that reason, when the air is extremely rarefied in one part, that which is more dense will immediately rush in to supply the vacant places, and preserve the equilibrium; as is the case with water and other fluid substances. Only raise a vessel of water suddenly out of a cistern, and see with what speed the other water will rush in, to fill up the space and preserve its level. And these rarefactions in the air may happen near the earth, or much above it; and is the reason why clouds fly in contrary directions. This occasioned the loss of the great kite, which we were a whole fortnight in making; for though there was scarcely wind in the park sufficient to raise it, yet when lifted extremely high by the air, it was

seized by a current of wind, and torn in pieces.

Winds are violent or gentle, in proportion to the rarefaction or disturbance there has been in the atmosphere. A violent wind, in a great storm, flies at the rate of 50 or 60 miles in an hour, and is often so dense, or strong, as to bear down trees, houses, and even churches before it. What the sailors call a brisk wind, flies at the rate of about 15 miles an hour, and is of great use in cooling the air, and cleansing it from poisonous and pestilential exhalations.

The winds have various qualities; they are generally either hot or cold, according to the quarter from whence they blow. In England, some years ago, they had a south-west wind in February, which blew so long from that quarter, that it brought them the very air of Lisbon; and it was as hot as in summer. Winds from the north and north-east, which come off large tracts of land, are generally cold. Some winds moisten and dissolve, others dry and thicken: some raise rain, and others disperse it: some winds blow constantly from one quarter, and are therefore called the General Trade Winds; these are met with on each side of the Equator, in the

Atlantic, Ethiopic, and Pacific Oceans. Some winds, again, blow constantly one way for one half, or one quarter of the year, and then blow the contrary way. These are met with in the East Indian seas, and are called Monsoons, or Periodical Trade Winds. But as these subjects are abstruse and difficult, and afford little entertainment, I will defer an explanation of them at present, and endeavour to give you some account of the meteors that attend the air.

We have already observed, that, besides pure air, the atmosphere contains minute particles of different sorts, which are continually arising in streams from the earth and waters, and are suspended and kept floating in the air.

The most considerable of these are the small particles of water; which are so separated as to be lighter than air, and are raised by the sun's heat, or lifted up by the wind from the sea, rivers, lakes, and marshy or moist parts of the earth; and which descend again in Dews, Rain, Hail, and Snow.

When these small particles are, by a rarefied state of the air, suffered to unite many of them together, and descend so as to render the hemisphere more opaque, and by its humidity to moisten bodies on the earth, it is

called a Mist. And, on the contrary, those particles of water that arise after a hot day from rivers, lakes, and marshy places, and, by filling the air, moisten objects and render them less visible, are called Fogs.

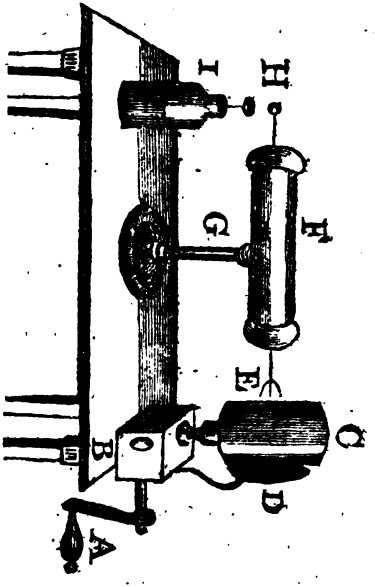
Clouds are the greatest and most beneficial of all the meteors, for they are borne about on the wings of the wind, and, as the Psalmist observes, "Distribute fatness to the earth." Clouds contain very small particles of water, which are raised a considerable distance above the surface of the earth; for a cloud is nothing but a mist flying high in the air, as a mist is nothing but a cloud here below.

That these vapours are raised in the air, in the manner above-mentioned, may be readily conceived; for it is an action that is seen every day in common distillations; but how these invisible particles which float in the air, are collected into clouds, in order to bring the water back again, is not so easy to determine. It is probable, that by uniting first into small drops, then into larger, they become too heavy to be suspended by the air, and fall down in rain.

We come now to describe the causes of Thunder and Lightning; but here I must take the Electrical Machine to my aid.

On account of the many late improvements that have been made in the science of electricity, the instrument-makers have made electrical machines upon various constructions. The one I am now going to describe is not the most modern of these; but as the essential parts are exactly the same in all, you will obtain by this a sufficiently complete and just information of the curious properties belonging to them.

All the phenomena called Electrical, are supposed to be effected by an invisible subtle fluid existing in all the bodies of the earth. The Electrical Machine is made to extract this fluid from the earth, in the manner I will describe to you.



The handle (marked A) being turned round, by means of some wheelwork in the box (marked B) turns round the glass cylinder (marked C); this cylinder rubs against the cushion of stuffed silk, which is called the Rubber (marked D): by this means the electric fluid is extracted from the rubber, and carried round by the glass to the points (mark-

ed E) which it enters, and remains in the tin tube or conductor (marked F), which is fixed upon a glass stem (marked G): as the electric fluid cannot pervade glass, this stem hinders it from returning again to the earth. When the machine is worked, if a person places one of his knuckles about half an inch from the brass knob at the end of the conductor (marked H) the electric fluid will dart like a bright spark of fire from it to the knuckle, and give the person a small degree of pain. If, instead of the knuckle, a coated jar is placed to the conductor, the fire will be received by it, and accumulated therein: so that if a person touches the bottom of the jar with one hand, and the ball at the top of it with the other, he will receive the charge of electricity through him, and feel the sensation of a sudden shock.

The similarity of lightning and electricity is not to be remarked in a few appearances only, but is observable throughout all their various effects. Lightning destroys edifices, animals, trees, &c. It always goes through the best conductors, such as metal or water; but if it meets with substances which will not conduct it (such as stone or wood) it rends them, and disperses them in every direction. Light-

ning burns, and often melts metals and other substances. All these effects, as I said before, may be produced by electricity. But beside the great similarity existing between lightning and electricity, what fully proves them the same is, that the matter of lightning may be actually brought down from the clouds by means of electrical kites: but as this is a very dangerous experiment in unskilful hands, I will not now describe the method of making them. Clouds have almost always some electrical matter in them; and the lightning accompanying, which is supposed to be collected from the earth with the thunder, is only that matter darting from one or more clouds into another cloud, or else upon the earth; in which case it strikes upon the most lofty and pointed places, and by this stroke produces all those dreadful effects that are known to be occasioned by lightning. But, says Miss Caroline, you have not yet mentioned those pointed rods on the tops of many large buildings; I have been told they protect the buildings from lightning. That they certainly do, Madam, said Master Telescope, for the lightning is attracted from the clouds by the pointed rod, and is by it conducted down the side of the building to the nearest

water, without damaging it. These rods were the invention of the late ingenious Dr. Franklin, of our own country. People in general, when they happen to be caught in a thunder-storm, run for shelter under a tree; but that that is very wrong; for the lightning is attracted by the tree, and thus accidents often happen. The best way is to get into an open place and lay at a distance all metal which you may have about you: if you do this, you are not in much danger of being hurt by the thunder and lightning.

Snow is the small particles of water frozen in the air before they had united into drops: and hail is drops of rain frozen in the fall.

The *Aurora Borealis*, or northern lights, are occasioned by certain nitrous and sulphureous vapours, which are thinly spread through the atmosphere, above the clouds, where they ferment, and, taking fire, the explosion of one portion kindles the next, and the flashes succeed one another, till all the vapour is set on fire, the streams whereof seem to converge towards the zenith of the spectator, or that point of the heavens which is immediately over his head.

At this instant, up started Master Long, and said, I should be glad to have an account

of this Jack-with-a-Lantern, which so haunts Mr. Setstar's park, and t'other day led my friend Tom Wilson into a large pond. Master Wilson, you are to understand, had been at his uncle's, where he had staid rather too late, and therefore his uncle ordered the footman to light him home; but Tom, being a very courageous fellow, and a little obstinate, would walk home alone, and in the dark: and just as he came into the marshy meadow, who should he almost overtake but this same gentleman, this Jack-with-a-Lantern, whom he mistook for Goody Curtis, the washer-woman, and thought she was lighting herself home from work. Tom ran to overtake Dame Curtis; but Mr. Jack with his Lantern still kept out of reach, and led my friend Tom out of the path; which he did not perceive till he had lost himself: on which Tom halloo'd, and Jack would not answer. At last souse came Tom into Duckweed pond, where he might have lain till this time, if Mr. Goodall had not heard him call out, as he was riding by, and went to his assistance. This put all the company in good humour; and Tom had good nature and good sense enough to join them in the laugh; which being sub-

sided, our Philosopher thus proceeded in his Lecture:

The *Ignis Fatuus*, *Jack-with-a-Lantern*, or *Will-with-the-Wisp*, as it is frequently called, is supposed to be only a fat, unctuous, and sulphureous vapour, which in the night appears lucid; and being driven about by the air near the earth's surface, is often mistaken for a light in a lantern. Vapours of this kind are in the night frequently kindled in the air, and some of them appear like falling stars; and are by ignorant people so called.

It may be here necessary to mention that beautiful phenomenon the Rainbow, since it has the appearance of a meteor, though, in reality, it is none; for the Rainbow is occasioned by the refraction or reflection of the sun's beams from the very small drops of a cloud or mist seen in a certain angle made by two lines, the one drawn from the sun, and the other from the eye of the spectator, to those small drops in the clouds which reflect the sun's beams: so that two persons looking on a Rainbow at the same time time, do not, in reality, see the same Rainbow.

There are other appearances in the atmosphere which ought to be taken notice of; and these are the halos, or circles, which some-

times seem to encompass the sun and moon; and are often of different colours. These always appear in a rainy or frosty season, and are therefore, we may suppose, occasioned by the refraction of light in the frozen particles in the air.

Here the Lecture would have ended, but a sudden clap of thunder brought on fresh matter for meditation. Some of the company, and particularly the ladies, endeavoured to avoid the lightning; but Master Telescope, after the second clap, threw up the sash, and assured the ladies and gentleman there was no danger, for that the clouds were very high in the air. The danger in a thunder storm, says he, is in proportion to the violence of the tempest, and the distance of the clouds; but this tempest is not violent; and that the cloud is at a great distance, or high in the air, you may know by the length of time there is between your seeing the flash of lightning and hearing the clap of thunder. Look, see how the sky opens to emit the fire! presently you will hear the thunder, for you know we see the fire from a gun at a distance, long before we hear the report. There it is! and how tremendous! These tempests always put me in mind of that beautiful passage in Shakes-

peare's King Lear; where, when the good old King is out in a storm, and obliged to fly from his unnatural children, he says,

——Let the great Gods
That keep this dreadful thund'ring o'er our heads,
Find out their enemies now. Tremble, thou wretch,
That haſt within thee undivulged crimes
Unwhipt of juſtice! hide thee, thou bloody hand,
Thou perjur'd, and thou ſimular of virtue,
That art incestuous! Caitiff, ſhake to pieces,
That under covert, and convenient ſeeming,
Has practis'd on man's life! Cloſe pent-up Guilt,
Rive your concealing continents, and ask
Theſe dreadful ſummoners grace!
This tempest will not give me leave to ponder
On things would hurt me more——

Poor naked wretches, whereſoe'er you are,
That bide the pelting of this pityleſs ſtorm!
How ſhall your houſeleſs heads, and unfed ſides,
Your loop'd and widow'd raggedneſs defend you
From ſeaſons ſuch as theſe?—O, I have ta'en
Too little care of this! Take phyſic, Pomp,
Expoſe thyſelf, to feel what wretches feel,
And thou may'ſt ſhake the ſuperflux to them,
And ſhew the Heavens more juſt.

LECTURE IV.

OF MOUNTAINS, SPRINGS, RIVERS, AND THE SEA.

WE come now, says the Philosopher, to the consideration of things with which we are more intimately acquainted, but which are not, on that account, the less wonderful. How was that Mountain lifted up to the sky? How came this crystal Spring to bubble on its lofty brow, or that large River to flow from its massy side? But above all, how came this mighty body of water, the Sea, so collected together? and why, and how was it impregnated with salt, seeing the fish and other animals taken out of it are perfectly fresh? These are questions not to be answered, even by the Sages in Science. Here the Philosopher, at the end of his judgment, and lost in admiration, can only say with the Psalmist, "They that go down into the sea, "and occupy their business in the great wa- "ters, these men see the greatness of God, "and his wonders in the deep.—Wonderful "are thy works, O Lord; in judgment hast

" thou made them all !—The earth is full of " thy greatness !

It is the business of Philosophy, however, to enquire into these things, though our enquiries are sometimes vain. We shall therefore, in this Lecture, give the best account we can of Mountains, Springs, Rivers, and the Sea.

The ancients supposed that Mountains were originally occasioned by the Deluge; before which time they imagined the earth was a perfect level: and a certain Abbot was taken into custody and punished for asserting that the earth was round; though there is so great a necessity for its being so, that, according to the properties with which the Almighty has endowed the substances that compose the world, it could not conveniently subsist in any other form; for, not to mention the formation of rivers, which are generally occasioned by the mists that fall on the mountains; if the earth was a regular plain, instead of that beautiful variety of hills and valleys, of verdant forests and refreshing streams, which at present delight our senses, a dismal sea would cover the whole face of the globe; and at best it would be only the habitation of fishes.

I protest, says Lady Caroline, I think you carry this argument too far, and seem to question the power of the Creator.—How can you tell that the earth and water thus disposed would have that effect?——From daily experience, Madam, says the Philosopher. Throw this stone into the moat, and you will see it sink; or this clot of dirt, and it will fall to the bottom. But, says she, this is not always the case; for when I water my flowers, the water sinks into the ground and disappears.—— That is, because there is abundantly more earth than water, Madam, says he; and the earth being porous, or hollow, the water runs into the cavaties, and fills them; but was you to continue pouring out of the water-pot till all these crevices were full, you would find the water flow at top, and the garden-mould, or earth, would remain at the bottom; for if you take a pint pot of earth, and another of water, and mix them ever so well together, the earth will in a little time subside or fall to the bottom, and the water will be seen at the top. This is to me a demonstration, Madam; and it is so far from calling in question the wisdom of God, that it is vindicating his wisdom in the works of Creation. So that you may perceive from hence, as well as from the

motion of the heavenly bodies, that the earth is round, and that the ancients were in an error.

And with regard to Mountains, though the Deluge might throw up many, and much alter the face of the earth, yet from the great use mountains are of in collecting the waters of the atmosphere into springs and rivers, it is reasonable to suppose there were mountains even in the first age of the world.

If I am not mistaken, says Mrs. Twilight, it has been supposed, and by men of learning, that this irregularity of the earth's surface was occasioned by some Comet's striking against it: and this opinion, I know, put Miss Lucy and many others in great pain when the late Comet was expected. What say you to this, young Gentleman?

I am unable to answer for all the extravagant conceits and ridiculous follies of the human race, Madam, says he; and you might as well expect me to give a reason for the poor soldier's prophesying an earthquake some time ago, and of the terrors of the people on that occasion, as to account for this. That the Earth has undergone amazing changes since its first formation, is, I think, evident from the contents of many mountains, in

various parts of the world. In some are found petrifactions in abundance; in others, the shells of sea-fish, the bones of animals, &c. At Reading, in Berkshire, (England,) which is above forty miles from the sea, there is a stratum of oyster shells, which appear like real oysters, and are spread through a hill of considerable extent; they lie upon a chalky rock in a bed of sand, much resembling that of the sea; and the upper part of the hill, which is a loamy soil, is thirty or forty feet perpendicular above them: and at Burton, near Petworth, in Sussex, was dug out of a pit, the bones or skeleton of an Elephant; and lately, in the state of New-York, the bones of an enormous quadruped have been discovered underneath the surface of the earth. Numberless curiosities of this kind have been discovered, (some of which I shall take particular notice of in my next course of Lectures); but I think there are few but what may be accounted for from the effects of the deluge, earthquakes, and subterraneous fires. Earthquakes at the bottom of the sea, for instance, have sometimes thrown up mountains or little islands, with the fish upon them, which have been covered by the sandy or loose earth giving way, and falling over them. It is not

long since an island was raised in this manner, in the Archipelago, of ten miles circumference, the hills of which abound with oysters not yet petrified, and which are much larger than those taken on the coast; whence we may conclude, that they were thrown up from the deepest part of the sea. Sea-fish have been also found in other mountains; some of which have been petrified, while others have been found with the flesh only browned or mummied.

And from the amazing quantity of fire contained in the earth, and of the subterranean air rarefied thereby, great alterations must have been made in its surface in the course of so many years.

Very well, says Lady Caroline; and so you are going to turn the earth into a hot-bed, and I suppose, we who are its inhabitants, are by-and-by to be complimented with the title of mushrooms and cucumbers, or perhaps pumpkins. This is fine philosophy, indeed. Have patience, my dear, says Mrs. Setstar.—Patience, Ma'am, returned Lady Caroline, why I hope your Ladyship would not have me believe that we have a furnace of fire under us? —I do not know, Madam, whether it be immediately under us or not, replied the little

Philosopher; but that there are numbers of these furnaces in the earth is beyond dispute, and is evidently proved by the great number of burning mountains, which are continually sending up flames, attended with large stones and metallic substances. I am sorry Mr. Galaxy is gone, Madam; for he would have set you right in this particular, which, pardon me, I shall not attempt, since I find my veracity so much questioned.—The company all laughed at the Philosopher in a pet; but Mrs. Setstar took up the matter, and soon put an end to the dispute. She blamed Lady Caroline for offering to decide upon a point which she did not understand; and then turning to the young gentleman, told him, that patience ought to be a principal ingredient in the character of a philosopher. Upon which Lady Caroline and he composed their difference with a mutual smile, and after asking the pardon of Mrs. Setstar for betraying too much warmth, even in the cause of truth, he told Lady Caroline, she should have some account of these mountains from the best authority; when, taking a book out of his pocket, he read as follows:

"The most famous of these mountains is Etna in Sicily, whose eruptions of flame and

smoke are discovered at a great distance, by those that sail on the Mediteranean, even as far as the harbour of Malta, which is forty German miles from the shore of Sicily. Though fire and smoke are continually vomited up by it, yet at some particular times it rages with greater violence. In the year 1536 it shook all Sicily, from the first to the twelfth of May; after that, there was heard a most horrible bellowing and cracking, as if great guns had been fired; there were a great many houses overthrown throughout the whole island. When this storm had continued about 11 days, the ground opened in several places, and dreadful gapings appeared here and there, from which issued forth fire and flame with great violence, which in four days consumed and burnt up every thing that was within five leagues of Etna. A little after, the funnel, which is on the top of the mountain, disgorged a great quantity of hot embers and ashes for three whole days together, which were not only dispersed throughout the whole island, but also carried beyond sea to Italy; and several ships that were sailing to Venice, at two hundred leagues distance, suffered damage. Facellus hath given us an historical account of the eruptions of this moun-

tain; and says, that the bottom of it is one hunded leagues in circuit.

"Hecla, a mountain in Iceland, rages sometimes with as great violence as Etna, and casts out great stones. The imprisoned fire often, by want of vent, causes horrible sounds, like lamentations and howlings; which make some credulous people think it the place of Hell, where the souls of the wicked are tormented.

"Vesuvius in Campania, not far from the town of Naples, though it be planted with most fruitful vines, and at other times yieldeth the best Muscadel wines, yet it is very often annoyed with violent eruptions. Dion Cassius relates, that in the reign of Vespasian, there was such a dreadful eruption of impetuous flames, that great quantities of ashes and sulphureous smoke were not only carried to Rome by the wind, but also beyond the Mediterranean, into Africa, and even into Egypt. Moreover, birds were suffocated in the air, and fell down dead upon the ground: and fishes perished in the neighbouring waters, which were made hot and infected by it. There happened another eruption in Martail's time, which he elegantly dercribes in one of his epigrams, and laments the sad change of

Mount Vesuvius.

the mountain, which he saw first in its verdure, and immediately after black with ashes and embers. When the burning ceased, the rain and dew watered the surface of the mountain, and made these sulphureous ashes and embers fruitful, so that they produced a large increase of excellent wine; but when the mountain began to burn again, and to disgorge fire and smoke afresh (which sometimes happened within a few years) then were the neighbouring fields burnt up, and the highways made dangerous to travellers.

"A mountain in Java, not far from the town of Panacura, in the year 1586, was shattered to pieces by a violent eruption of glowing sulpher (though it had never burnt before); whereby (as it was reported) ten thousand people perished in the under-land fields. It threw up large stones, and cast them as far as Panacura; and continued for three days to throw out so much black smoke, mixed with flames and hot embers, that it darkened the face of the sun, and made the day appear as the night."

There are a great number of other mountains, or (as your Ladyship is pleased to call them) furnaces in the known world; to enu-

merate them would be too tedious to my auditors.

We come now to the consideration of Springs; which are occasioned principally, we may suppose, by the water exhaled from the sea, rivers, lakes, and marshy places; and, forming clouds, are dispersed by the winds. These clouds, when they are so collected together as to become too heavy to be supported by the air, fall down in rain to water the herbs and plants; but those that are lighter, being driven aloft in the air, dash against the mountains, and to them give up their contents in small particles; whence entering the crevices, they descend till they meet together, and form springs: and this is the reason why we have such plenty of springs in mountainous countries, and few or none in those that are flat. And you may observe that it frequently rains in hilly countries, when it is clear and fine in the vallies beneath; for the air in the vallies is dense enough to support the clouds, and keeps them suspended; but being driven up among mountains, where, in consequence of their height, the air is so much lighter, they descend in mists or such small drops of rain that will not run off, as is the case in a heavy rain, but sink into the crevices of the

earth, in the manner already mentioned. Now, that a great part of this water is exhaled from the sea, may be known by the extraordinary rains and great dews which fall upon islands that are surrounded by the sea; but some springs, it is reasonable to suppose, have their source from the ocean, since those which we meet with near the sea are generally somewhat salt or brackish.

These springs, thus formed by the mists on mountains, and the rain meeting together, form little rivulets or brooks; and those again uniting, compose large rivers, which empty themselves into the sea: and in this manner the water, exhaled from the sea by the sun, is returned to it again; for Providence has established such wise laws or regulations for the world, that no part of the element can be annihilated. But the very large rivers must have some other source besides the springs formed by the mists, dews, and rains, since these seem insufficient to support their prodigious discharge; it is therefore no improbable conjecture, to suppose that they have some communication with the sea, and that the salt water is purified and rendered sweet by passing through the sand, gravel, and crevices of the earth.

Lakes are collections of water contained in the cavities of the surface of the earth; some of which are said to be stagnant, and made up of the waste water that flows, after rain or snow, from the adjacent countries; and these must be unwholesome.—Other lakes are supplied by rivers, the contents of which they receive and convey under ground, to form other springs and rivers; others, again, are fed by springs which arise in the lake itself; and some (as that of Haerlem, and other salt lakes) have a communication, it is supposed, with the sea, whence they receive their waters, and afterwards discharge them by subteranean streams.

The sea is a great collection of water in the deep vallies of the earth; I say, in the deep vallies; for if there were not prodigious cavities in the earth, to contain this amazing quantity of water, thus collected together, the whole surface of the globe would be overflowed; for the water being lighter than the earth, would be above the earth, as the air is above the water.

Now you speak of the sea, says Mrs. Setstar, I wish you would tell me why the sea-water is always salt. Madam, replied he, I

wish I could; but it is beyond the reach of my philosophy, and indeed, I believe, of any philosopher whatever; although some have conjectured, that the rivers in their passage extract the salts from the earth, and convey them to the sea.

I have often thought, from the prodigious quantity of salt distributed in the earth and water, that it must have qualities which we know not of, and answer purposes in the scale of being with which we are unacqainted.

The most remarkable quality in the sea, next to its saltness, is that motion or rising and falling of the water, which we call tides, and which is occasioned by the attraction of the moon; which I mentioned in my second Lecture (page 26); for that part of the water in the great ocean which is nearest the moon, being strongly attracted, is raised higher than the rest; and the part opposite to it, on the contrary side, being least attracted, is also higher than the rest; and these two opposite sides of the surface of the water, in the great ocean, following the motion of the moon from east to west, and striking against the large coasts of the continent, from thence rebound

back again, and so make floods and ebbs in narrow seas and rivers, at a distance from the great ocean. This also accounts for the periodical times of the tides, and for their constantly following the course of the moon.

LECTURE V.

OF MINERALS, VEGETABLES, AND ANIMALS.

COULD a Philosopher condescend to envy the great, it would not be for their sumptuous palaces and numerous attendants, but for the means and opportunities they have of enquiring into the secrets of Nature, and contemplating the wonderful works of God. There is no subject so worthy of a rational creature, except that of promoting the happiness of mankind; and none, except that, can give a man of refined taste and good understanding, so much real satisfaction. But it is our misfortune that few engage in those enquiries but men of small estate, whose circumstances will not permit them to spare the time, nor support the expence of travelling, which is often necessary to obtain the knowledge they seek after; and for the want of which they are obliged to depend on the relations of those who have not, perhaps, been so accurate or so faithful as they ought. Considering the quantity of drugs that are used, it

is amazing how little even those who deal in them know of the matter: so little, indeed, that they cannot tell where they grow, or how they are found or manufactured; are unable to distinguish the genuine from the spurious, and may therefore, through mistake, often substitute the one for the other. Health and life are of too much consequence to be trifled with; yet these are neglected, while fashion, dress, and diversions, are sought after throughout the world. This is a melancholy consideration; but this, you'll say, is no part of our Lecture, therefore we shall drop a subject which has thrust itself, as it were, into our way, and speak of the contents of the earth, and its products and inhabitants; for this globe, besides the earth and water, which are necessary for the production and support of plants and animals, contains other materials which have been found useful to man. That reflecting telescope, this gold watch, and Lady Caroline's diamond ear-rings, were all dug out of the earth; at least the materials were there found, of which these things are composed.

Those sorts of earth, which, with the assistance of rain produce vegetables or plants in such abundance, are common mould, loam,

clay, and sandy soils. There are earths also that are different from these, and which are used in medicine; as the Japan earth, Armenian Bole, &c.

The barren parts of the earth are, for the most part, sand, gravel, chalk, and rocks; for these produce nothing, unless they have earth mixed with them.—Of barren sands there are various kinds, though their chief difference is in their colour; for the sand which we throw on paper to prevent blotting, and that the maid throws on the floor, are both composed of little irregular stones, without any earth; and of such there are large deserts in some parts of the world, and one in particular, where Cambyses, an eastern monarch, lost an army of 50,000 men.——Sure, says Lady Caroline, you must mistake, Sir. How was it possible for a whole army to be lost in that manner? Why, Madam, returned the philosopher, the wind, as it frequently does in those parts, raised the sands and clouds, for many days together, and the whole army was smothered. And if you read the life of Alexander the Great, you'll find, Madam, that his army was in great danger, when he crossed the same desert, in his frantic expedition to visit the temple of his

pretended father, Jupiter Ammon.——But we return to our subject.

Besides these materials, which compose the surface of the earth, if we dig deeper, we frequently find bodies very different from those we discover near the surface; and these, because they are discovered by digging into the bowels of the earth, are called by the common name of Fossils; though under this head are included all metals and metallic ores, minerals, or half metals, stones of various sorts, petrifactions, or animal substances turned into stone; and many other bodies which have a texture between stone and earth; as oker of several sorts, with one of which the farmers colour their sheep; black lead, with which are made those pencils that we use for drawing; and some kinds of chalk, sea-coal, and other bodies that are harder than earth, and yet not of the consistency of perfect stone.

Of stones there is an amazing variety. They are classed by naturalists under two heads; that is to say, spars and chrystals: and by others, into vulgar and precious stones. Some of the most considerable, both for beauty and use, are marble, alabaster, porphyry, granite, free-stone, &c. Flints, agates,

cornelians, and pebbles, under which kind are placed the precious stones, otherwise called gems or jewels; which are only stones of an excessive hardness, and which, when cut and polished, have an extraordinary lustre. The most valuable of these are diamonds, rubies, sapphires, amethysts, emeralds, topazes, and opals.

But there are other stones which, tho' void of beauty, may, perhaps, have more virtue than many of those already mentioned; such as the loadstone, which I described to you in my first Lecture (p. 11.); also the whetstones, with which we sharpen our knives and other edge-tools; limestones, talc, calamine, or lapis calaminaris, and many others.

Besides the bodies already mentioned, there are also found in the earth a variety of salts; such as rock-salt or sal-gem, vitriol, nitre, and many others.

The minerals, marcasites, or semi-metals, as they are called by the chemists, are antimony, zink, bismuth, &c. These are not inflammable, ductile, or malleable, but are hard and brittle, and may be reduced to powder; and the first, after melting, may be calcined by fire.

Mercury, or quicksilver, has generally been classed with semi-metals, and indeed, sometimes among the metals; but I think it ought not to be classed under either of these heads, but considered seperately; as also should brimstone, though it be a part of the composition of crude antimony.

Ores are those kinds of earth which are dug out of mines, and that contain in them metallic particles, from whence metals are extracted.

Their form when dug from the mine is very different from that which they assume when they have been melted in the furnace, and polished by the art of man. The most precious metals, as gold and silver, do not form the most splendid ores. The pyrites, which are a mixture of iron and sulpher, are much more beautiful to the eye.

The trade of a miner is the most wretched and dangerous of all; they are not only exposed to the common accidents of the roof falling in, or a sudden overflow of water, but also a variety of *damps*, as they are called, or noxious vapours. In the quicksilver mines, the sufferings of the workmen are deplorable; their bodies are so impregnated with the mineral, that they soon become emaciated and

crippled, every limb contracted or convulsed, and soon end their miserable existence in a consumptive state: and this they sustain for the trifling reward of seven pence a day.

Metals are distinguished from other bodies by their weight, fusibility, or melting in the fire, and their malleability, or giving way and extending under the stroke of the hammer without breaking in pieces. These are six, viz. gold, silver, copper, tin, lead, and iron. They are seldom or never found in any part of the earth but what is mountainous, which, by the way, in some measure proves what we ventured to assert in a former Lecture, viz. that there were mountains before the deluge; for that there were metals before that time, appears by what is said in holy writ concerning Tubal Cain, who wrought in brass, &c. and was the inventor of organs.

What sort of bodies are to be found deeper in the earth, I mean towards its centre, is unknown to us; for we can only make ourselves acquainted with the fossils contained in its shell, and the vegetables and animals on its surface, whose nature and properties alone are, indeed, too many, to be discovered by human sagacity.

OF VEGETABLES OR PLANTS.

The vegetables or plants growing on the earth, may be divided into three classes; I mean those of herbs, shrubs, and trees.

Herbs are those sorts of vegetables whose stalks are soft, and have no wood in them; as parsley, lettuce, violets, pinks, grass, nettles, thistles, and an infinite number of others.

Shrubs are those plants which, though woody, never grow into trees, but bow down their branches near the earth's surface. Such are those plants that produce roses, honeysuckles, gooseberries, currants, and the like.

But trees shoot up in one great stem or body, and rise to a considerable distance from the ground, before they spread their branches; as may be seen by the oak, the beech, the elm, the ash, the fir, the walnut-tree, cherry-tree, &c. From the bodies of trees we have our timber for building; and of the oak-tree in particular for ship-building, no timber being so tough, strong, and durable, as oak; neither does any tree, perhaps, yield more timber.

" From a ſmall acorn ſee the oak ariſe,
Supremely tall, and tow'ring to the ſkies!
Queen of the groves, her ſtately head ſhe rears,
Her bulk increaſing by the length of years:
Now ploughs the ſea, a rich, commercial ſhip,
Or in her womb deſtructive thunders ſleep.

The most considerable parts of plants are the root, the ſtalk, the leaves, the flowers, and the seed; most of them have these several parts, though there are some, indeed, that have no ſtalk, as the aloe; others that have no leaves, as ſavine; and others that have no flowers, as fern. But I think there are none without root or seed.

What most excites our wonder with reſpect to plants (and what, indeed, has been the ſubject of much diſpute among the learned) is their nourishment and propagation.—— This, ſays Maſter Blossom, I have often heard my father diſcourse upon when I have been in the garden with him; but as what he ſaid has escaped my memory, I ſhould be glad, Sir, if you would tell me how they receive their nourishment, and how their ſpecies are propagated. A diſquiſition of this nature, says the little philoſopher, would take up too much of your time, and could not be underſtood without reciting ma-

ny experiments and observations that have been made by the learned: I shall therefore defer the consideration of it at present. I see no reason for that, says Master Wilson; nor to me does there appear any difficulty in the affair. Why, they receive their nourishment from the earth, don't they? And you sow the seeds of the old plants, and they produce new ones.

You are too apt, Master Wilson, says the philosopher, to talk about things you don't understand. The earth has not, perhaps, so much to do with the nourishment of plants as is generally imagined; for, without water, and particularly rain-water and dew, there could be but little increase in vegetables of any kind; and this you may know by the languid state of plants in a dry season, though watered ever so often from the river or well. This is known also by the small quantity of earth which is taken up in the growth of plants; for both Mr. Boyle and Dr. Woodward raised several plants in earth watered with rain or spring-water, and even distilled water; and upon weighing the dry earth, both before and after the production of the plants, they have found that very little of it was diminished or taken up by the plant. Taken up by the plant!

says Lady Caroline, in some surprise; why, you don't imagine there is earth in herbs and trees?—Indeed I do, Madam, replied the little philosopher, and have already hinted as much in what was said on the four elements, and at the same time told your Ladyship, if I mistake not, how it might be extracted from the plant; which was, by burning the plant to ashes, and washing off the salts, as your laundry-maid does when she makes lye; for when those salts are washed away, the remainder will be earth.

If the earth contributes so little towards the production of plants, says Blyth, the water, I apprehend, must be a good deal concerned; and that is evident from the quantity of water which most plants require to keep them in a state of health and vigour.—Your observations, says the philosopher, deserve some notice; but how will you account for the growth of plants in sandy desarts, where it seldom rains, and of plants too that contain juices in great abudance? for God Almighty, for the preservation of his creatures, has caused those wonderful plants to grow in such barren desarts, to supply in some measure the want of water; and some are so constructed as to hold great quantities of water for the use of

animals. This is the case of the ground-pine; which, tho' it seems to grow like a fungus or excrescence on the branch of a tree, often contains a pint or a quart of sweet water for the birds, beasts, and even men, to refresh themselves with in the sultry climates where they abound. But a plant may hold much water for the subsistence of animals, and yet not subsist on water itself; and that this is the case experience testifies. Dr. Woodward put a plant of spearmint, which weighed 27 grains, into a phial of water, where it stood 77 days, and in that time drank up 2,558 grains of spring water: and then being taken out, weighed 42 grains; so that the increase was only 15 grains; which is not an hundreth part of the water expended.

What the plant can obtain by the earth, water, and otherwise, for its nourishment, is generally supposed to be received by the fibres of the roots, and conveyed by the stalk or body of the plant up into the branches and leaves through small tubes, and then returned by the bark to the root again; so that there is a constant circulation of vital fluids in plants as well as in animals. But I am inclined to think, that a great part of the nourishment of plants is received by the pores of the leaves

and skin, or bark, as well as from the root; else how happens it that plants are so much refreshed by the dew?

Plants also require air for their nourishment, as well as a circulation of these alimentary juices; for they respire as well as animals, and for that respiration require fresh air, and even exercise; since we know that plants that are always confined in a close room will never rise to perfection: and that they perspire as well as animals is evident, from the instance of the mint growing in spring-water above-mentioned; for, if not a hundreth part of the water taken up by that plant became a part of the plant itself, all the rest must be perspired through the pores or little imperceptible holes in the skin and leaves.—This calls to my mind, says Lady Caroline, a charge Mr. Setstar gave me; which was, never to sit in the yew-arbor; for the matter perspired by the yew-tree, says he, is noxious, and will make you ill; and I believe that was the reason of his ordering that old arbor to be demolished.

But pray why, and in what manner do plants perspire? For the same reason, and in the same manner, perhaps, that animals do, returned the philosopher. It is occasioned, probably, by heat; for we know they perspire

abundantly more in summer than in winter; nay, when this vegetative principle has been long checked by cold, it breaks out with such force when warm weather comes on, that it is no uncommon thing, in the cold northern countries, to see the trees covered with snow one week, and with blossoms the next.

Plants are propagated different ways; but the most general method is by seed. Some plants, however, are raised by a part of the root of the old plant set in the ground, as potatoes; others, by new roots propagated from the old ones, as hyacinths and tulips; others by cutting off branches, and putting them into the ground, which will there take root and grow, as vines; and others are propagated by grafting and budding, or inoculation.

OF ANIMALS.

We are now to speak of the animals that inhabit the earth, which are naturally divided into Men and Brutes.

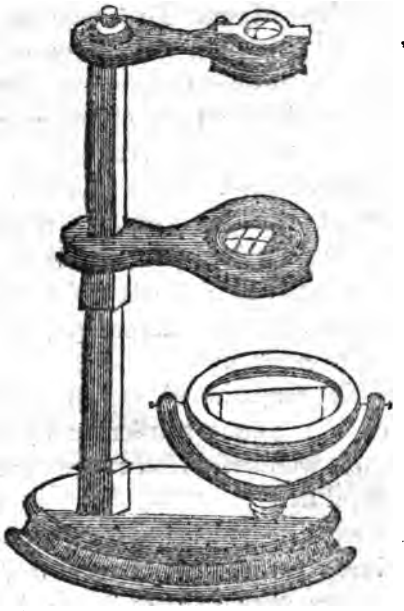
Of Men, there seem to be four different sorts.—Nay, don't be frightened, Lady Caroline!——Sir, says she, I should have made no objection, had you said four hundred, provided you had distinguished them according to their different dispositions.——True, Madam, says the philosopher, or according to their different features, and then you might have said four hundred thousand; for it is very true, though very wonderful, that out of four hundred thousand faces you will not find two exactly alike; and but for this miraculous and gracious providence in God, the world would have been all in confusion. But the division I would willingly make of men, Lady Caroline, is that of white, tawny, black, and red; and these you will allow are, with respect to colour, essentially different. Most of the Europeans, and some of the Asiatics, are white; the Africans on the coast of the Mediterranean Sea are tawny;

those on the coast of Guinea black; and the original Americans red, or of a red copper colour. How they came so, is only known to their Maker; and therefore I beg you would spare yourselves the trouble of asking me any question on that head.

Brutes may be divided into four classes; that is to say, 1. Aerial, or such as have wings, and fly in the air; as birds, wasps, flies, &c. 2. Terrestrial, or those which are confined to the earth; as quadrupeds, or four-footed beasts; reptiles which have many feet; and serpents, which have no feet at all. 3. Aquatic, or those that live in the water; as fish of all kinds, whether they are covered with scales or shells, or are, like the eel, without either. 4. Amphibious, or those that can live for a long time either upon the earth or in the water; as otters, aligators, turtles, &c. I say for a long time, because I apprehend that the use of both these elements are necessary for the subsistence of those animals; and that though they can live for a considerable time upon land in the open air, or as long in the water, excluded in a manner from air, yet they would languish and die if confined entirely either to the one or the other of these elements.

In this division of animals we are to observe, however, that there are some which cannot be considered under either class, being, as it were, of a middle nature, and partaking of two kinds: thus, bats seem to be partly beasts and partly birds. Some reptiles, likewise, and some of the water-animals, want one or more of the five senses with which others are endowed; as worms, cockles, oysters, &c.—If I mistake not, says Lady Caroline, I have seen the animals divided into different classes in books of natural history, and described under the heads of beasts, birds, fishes, and insects. Very true, says the philosopher, but the present method suits my present purpose the best, and can make no alteration in the nature of things; however, as I have not yet mentioned the word Insects, though they are included in my division of animals, it may be necessary for me to observe, that they are so called from a separation in their bodies, by which they are seemingly divided into two parts, those parts being only joined together by a small ligament; as in flies, wasps, &c. Some of these insects undergo different changes, and in time become quite different animals. There is something so amazing and

miraculous in the transformation of insects, that I am lost in reflection whenever the subject strikes my mind; and sometimes inclined to think that other animals may undergo some such change. Who, that had not made the observation, would think that this grub, crawling, or rather sleeping here, would by-and-by become a fine butterfly, decked out in all the gaudy colours of the rain-bow; or that this silkworm should be capable of assuming so many different forms! And is it not altogether as miraculous, that if some animals are cut in pieces, every separate piece or part of the original animal will become one entire animal of itself: Yet that the polype or polypus is endowed with this property, has been demonstrated; and I have here one that was divided into several parts some time ago, which parts are now become distinct and perfect polypes, and alive; as you may see by viewing them through this microscope.



The part marked A, contains the magnifying glasses. The object to be examined is placed at the stage B, between a hollow and a plane glass; the light is reflected upon it by the mirror C. To adjust the object to the glasses, you move the stage B up or down upon the pillar, while you are looking through

the glasses at A, till the objects appear the most distinct.—Master Telescope then placed one of the polipes in the microscope, and begged Lady Caroline to look at it.—This is really wonderful, says Lady Caroline, for the polypus seems now to be 40 or 50 times bigger than it was before. Your wonder will be increased still more, Madam, replied our philosopher, when I inform you, that it is supposed there are as many animals which can only be discovered by the microscope, as those we can see without it.

Master Telescope having satisfied the curiosity of the young gentlemen by letting them see this wonderful instrument, proceeded in his Lecture.

But the sagacity and acute senses of some of the animals (in which they seem to exceed man) are altogether as surprising: beavers building houses; bees forming themselves into a society and chusing a queen to govern them; birds knowing the latitude and longitude, and sailing over sea, through vast tracts of air, from one country to another, without the use of any compass; and other things, which are sufficient, I think, to lower the pride of man, and make even philosophers blush at their own ignorance.—And now, La-

dy Caroline, prepare to hear a few hard words, and I will finish this Lecture. But why must it be finished in an unintelligible manner? says the Lady. Because I cannot deliver what I am going to say, without making use of the terms of art; and those I would recommend your Ladyship, and the rest of the good company, to learn from *Walker's Pronouncing and Explanatory Dictionary;* which is a work no young reader should omit having in his library.

All animals receive their food at the mouth; and most animals, but especially those of the human kind, chew it there till it is intimately mixed with the saliva or spittle, and thereby prepared for the easier and better digestion of the stomach. When the stomach has digested the food, it is thence conveyed into the guts (pardon the expression, Ladies, for I cannot avoid it) through which it is moved gently by what is called the peristaltic motion; as it passes there, the chyle, which is the nutritive part, is separated by the lacteal veins, from the excrementitious parts, and by them conveyed into the blood, with which it circulates, and is concocted into blood also; and this circulation is thus performed:—The blood being, by the *vena*

cava, brought into the right ventricle of the heart, by the contraction of that muscle, is forced into the pulmonary artery of the lungs; where the air, which is continually inspired or drawn in by the lungs, mixes with and enlivens it; and from thence, the blood being conveyed by the pulmonary vein into the left ventricle of the heart, the contraction of the heart forces it out, and by the arteries distributes it into all parts of the body; from whence it returns by the veins to the right ventricle of the heart, to pursue the same course again, in order to communicate life and heat to every part of this wonderful machine, the body. But this is not all; for, according to Anatomists, some part of the blood, in the course of its circulation, goes to the head; where a portion of it is separated by the brain, and concocted into animal spirits, which are distributed by the nerves, and impart sense and motion throughout the body. The instruments of motion, however, are the muscles; the fibres, or small threads whereof, contracting themselves, move the different parts of the body; which in some of them is done by direction of the mind, and called voluntary motion; but, in others, the mind seems not

to be concerned, and therefore these motions are called involuntary.

This is the progress of animal life; by which you will perceive that a man may, even at home, and within himself, see the Wonders of GOD in the Works of Creation.

We have now finished our survey of the Universe, and considered those great masses of matter, the Stars and Planets; but particularly our earth and its inhabitants; all which large bodies are made up of inconceiveable small bodies, or atoms: And by the figure, texture, bulk, and motion of these insensible corpuscles, or infinitely small bodies, all the phænomena of large bodies may be explained.

LECTURE VI.

OF THE FIVE SENSES OF MAN, AND OF HIS UNDERSTANDING.

AT our next meeting there was a great deal of good company, who came to hear the Boys Philosophy, as they called it; on which account I could observe that Master Telescope took less pains to be understood by the young gentlemen and ladies; and addressed himself more particularly to those of greater abilities.

As the company came in laughing, and affected to talk and behave in a supercilious manner (which even some great personages do in these our days of refinement) he stood silent till Mr. Setstar desired him to open the Lecture; upon which he began; but had scarcely spoken three words before he was interrupted by Master Harry: he therefore stopped for some time, and then began again; but the tongue of the young gentleman soon silenced him; and he stood without speaking a considerable time. On this the company looked at each other; and Mr. Setstar bade

him go on. My dear, says Mrs. Setstar, how can you expect this young gentleman to read a long Lecture, when you know that Master Harry, who loves to hear himself talk, of all things, has not patience to support so much taciturnity?——Why, Madam, says the Ambassador of Bantam (who came in with Mr. Setstar,) I thought we had all been assembled to hear this Lecture.——That was indeed the intention of our meeting, says the Lady; but I hope you know the polite world better, than to expect people should be so old-fashioned as to behave on these occasions with any sort of good manners or decorum. In my country, says the Ambassador, all the company keep a profound silence at these meetings.—— It may be so, replied Mrs. Setstar; but I assure your excellency, it is not the custom here. Why, Sir, I have been often interrupted in the middle of a fine air, at an Oratorio, by a gentleman whistling a hornpipe; and, at Concerts of Sacred Music it is no uncommon thing to hear both gentlemen and ladies laugh louder than the organ.——Hush, Madam, says Mr. Setstar, if your friends and neighbours are fools, you ought not to expose them, and especially to foreigners. Take care, while you condemn this unpolite beha-

viour in others, that you do not run into it yourself. Politeness is the art of being always agreeable in company; it can therefore seldom deal in sarcasm or irony; because it should never do any thing to abridge the happiness of others; and you see, my dear, you have made Master Harry uneasy, for he blushes.——The company laughed at Harry, who joined them; and being determined to hold his tongue, our Philosopher thus proceeded:

After the cursory view of nature, which was concluded in my last Lecture, it may not be amiss to examine our own faculties, and see by what means we acquire and treasure up a knowledge of those things; and this is done, I apprehend, by means of the senses, the operations of the mind, and the memory; which last may be called the Storehouse of the Understanding. The first time little master is brought to a looking-glass he thinks he has found a new play-mate, and calls out, Little boy! Little boy! for having never seen his own face before, it is no wonder that he should not know it. Here is the idea, therefore, of something new acquired by sight.—— Presently the father, and mother, and nurse come forward to partake of the child's diver-

sion. Upon seeing these figures in the glass with whom he is so well acquainted, he immediately calls out, There, Papa! there Mamma! there, Nurse!——And now the mind begins to operate; for feeling his father's hand on his own head, and seeing it on the little boy's head in the glass, he cries, There me! Now this transaction is lodged in the memory, which, whenever a looking-glass is mentioned, will give back to the mind this idea of its reflecting objects.

The whole company were pleased with this familiar demonstration; but Harry asked how he came, of all things, to make use of a looking-glass?——Because, Sir, says he, it is an object with which some people are the most intimately acquainted.——As Harry is an egregious fop, this reply produced a loud laugh; and Master Telescope was looked upon to be a Wit, as well as a Philosopher. However, I am inclined to think the expression was accidental, and not intended to hit Master Harry, because I know his good sense would not permit him to treat an elder and superior in that manner.——The laugh being a little subsided, our Philosopher thus proceeded on his Lecture:——

All our ideas, therefore, are obtained either by sensation or reflection; that is to say, by means of our five senses; as seeing, hearing, smelling, tasting, and touching, or by the operations of the mind.

Before you proceed farther, says Mrs. Twilight, you should, I think, explain to the company what is meant by the term Idea.—— That, I apprehend, is sufficiently explained by what was said about the looking-glass, says the Philosopher; but if you require another definition, you shall have it. By an Idea, then, I mean that image or picture which is formed in the mind, of any thing which we have seen, or even heard talk of; for the mind is so adroit and ready at this kind of painting, that a town, for instance, is no sooner mentioned, but the imagination shapes it into form, and presents it to the memory. None of this company, I presume, have ever seen Paris; yet there is not one, perhaps, but has formed, or conceived in his mind, some idea or picture of that city. Not one of us ever saw Tippoo Saib's prodigious army and elephants, yet we have all formed to ourselves a picture of their running away from a small party of Englishmen, led against them by the courageous Cornwallis. When we read in

the news-papers a description of a sea engagement, or the taking of Luisbourg, Quebec, or any other important fortress, the mind immediately gives us a picture of the transaction, and we see the officers issuing their orders, and their intrepid men furling their sails, firing guns, scaling the walls, and driving their foes before them. To pursue this subject a little farther: No man has ever seen a dragon, a griffin, or a fairy; yet every one has formed in his mind a picture-image, or, in other words, an idea of these imaginary beings. Now when this idea or image is formed in the mind from a view of the object itself, it may be called an adequate or real idea; but when it is conceived in the mind without seeing the object, it is an inadequate or imaginary idea.

I shall begin my discourse of the Senses with that of the Sight, says he, because, as Mr. Addison observes, the sight is the most perfect and pleasing of them all. The organ of seeing is the eye, which is made up of a number of parts, and so wonderfully contrived for admitting and refracting the rays of light, that those which come from the same point of the object, and fall upon different parts of the pupil, are again brought together at the bottom of the eye; and by that means

the whole object is painted on a membrane called the Retina, which is spread there.

But how is it possible, says Master Harry, for you to know that the object is thus painted on the retina?——In some measure from the structure of the eye, replied the Philosopher; but, I think, it is manifest from that disorder of the eye, which surgeons call the *gutta serena;* the very complaint which Mr. Setstar's butler has in one of his eyes. If you examine it, you will find that he has no sight with that eye, though it looks as perfect as the other, with which he sees well; this is, therefore, occasioned by some paralytic, or other disorder in that membrane, or expansion of the optic nerve, which we call the Retina; and proves that all vision arises from thence.

That which produces in us the sensation which we call Seeing, is light; for without light nothing is visible. Now light may be considered either as it radiates from luminous bodies directly to our eyes; and thus we see these luminous bodies themselves; as the Sun, a lighted torch, &c.——or as it is reflected from other bodies; and thus we see a flower, a man, &c. or a picture reflected from them to our eyes by the rays of light.

It is to be observed, that the bodies which respect the light are of three sorts, 1. Those that emit the rays of light; as the sun and fixed stars: 2. Those that transmit the rays of light; as the air: and, 3. Those that reflect them; as the moon, the earth, iron, &c. The first we call Luminous, the second Pellucid, and the third Opaque Bodies. It is also to be observed, that the rays of light themselves are never seen; but by their means we see the luminous bodies, from which they originally came; and the opaque bodies, from which they are reflected; thus, for instance, when the moon shines, we cannot see the rays which pass from the sun to the moon; but, by their means, we see the moon, from whence they are reflected.

If the eye be placed directly in the medium, through which the rays pass to it, the medium is not seen; for we never see the air through which the rays come to our eyes. But if a pellucid body, through which the rays are to pass, be placed at a distance from our eye, that body will be seen, as well as those bodies from whence the rays came that pass through it to our eyes. For instance, he who looks through a pair of spectacles, not only

sees bodies through them, but also sees the glass itself; because the glass, being a solid body, reflects some rays of light from its surface; and being placed at a convenient distance from the eye, may be seen by those reflected rays at the same time that bodies at a greater distance are seen by the transmitted rays; and this is the reason, perhaps, why objects are seen more distinctly through a reflecting than through a refracting telescope.

There are two kinds of opaque bodies; namely, those that are not specular; as the moon, the earth, a man, a horse, &c. and others that are specular, or mirrors, like those in reflecting telescopes, whose surfaces, being polished, reflect the rays in the same order as they came from other bodies, and show us their images; and rays that are thus reflected from opaque bodies always bring with them to the eye the idea of colour, though this colour in bodies is nothing more than a disposition to reflect to the eye one sort of rays more copiously, or in greater plenty than another; for particular rays impress upon the eye particular colours; some are red, others blue, yellow, green, &c. Now it is to be ob-

served, that every body of light which comes from the Sun, seems to be compounded of those various sorts of rays; and as some of them are more refrangible than others, that is to say, are more turned out of their course in passing from one medium to another, it necessarily follows that they will be separated after such refraction, and their colours appear distinct. The most refrangible of these are the violet, and the least the red: the intermediate ones, in order, are indigo, blue, green, yellow, and orange.

How do you know, Mr. Philosopher, that colours are separated in this manner? says Master Harry: I have no notion of these doctrines without demonstration.——That you may have, if you please, replied the Philosopher. Pray, Master Lovelace, hand me that Prism.

Now, Master Harry, if you will please to hold this Prism in the beams of the Sun, you will see the colours separated in the manner I have mentioned. Please to look, Lady Caroline; the separation is very pleasing, and you will find what I have said of the rainbow in my third Lecture, confirmed by this experiment.

All these rays differ not only in refrangibility, but in reflexibility; I mean the property some have of being reflected more easily than others; and hence arise all the various colours of bodies.

The whiteness of the Sun's light is owing, it is supposed, to a mixture of all the original colours in a due proportion; and whiteness in other bodies is a disposition to reflect all the colours of light nearly in the same proportion as they are mixed in the original rays of the Sun; as blackness, on the contrary, is only a disposition to absorb or stifle, without reflection, most of the rays of every sort that fall on those bodies; and it is for that reason, we may suppose, that black clothes are warmer than those of any other colour. The inhabitants of Naples, though in so hot a clime, for the most part wear black.

Hearing is the next most extensive of our senses, the organ of which is the Ear, whose structure is extremely curious; as may be seen in the books of Anatomy.

That which the ear conveys to the brain is called Sound, though till it reaches and affects the perceptive part, it is in reality nothing but motion; and this motion, which produces in us the perception of sound, is a vibration of the air occasioned by a very short and quick tremulous motion of the body from whence it is propagated. That sound is conveyed in this manner, may be known by what is observed and felt in the strings of musical instruments, and of bells, which tremble or vibrate as long as we perceive any sound come from them; and from this effect which they produce in us, they are called sounding bodies.

Sound is propagated at a great rate; but not near so fast as light.——I don't know that, says Lady Caroline.——Then you have forgot what passed in our Lecture upon Air, replied the Philosopher; and to confirm by experiment what I advanced, I must beg that one of the servants go to a distance into the park, and discharge a gun.——The gentlemen were averse to this; it being an observation

they had made a hundred times; but to gratify the young people, Mr. Setstar ordered his game-keeper out; and when the piece was discharged, they had the satisfaction of seeing the fire long before they heard the report.

The effect is the same, says our philosopher, in thunder storms, for we perceive the flash of lightning before we hear the thunder; and the more distant the storm is from us, the greater is the space of time between the flash and report.

Smelling is another sense which seems to be excited in us by external bodies, and sometimes by bodies at a great distance; but that which immediately affects the nose, the organ of smelling, and produces in us the sensation of any smell, are effluvia, or invisible particles that fly from those bodies to our olfactory nerves.—How do you prove this, young gentleman? says Master Harry.—Sir, replied the Philosopher, had you been here yesterday, you would not have asked this question; for, as the wind was north-east, the effluvia from those brick-kilns were ready to suffocate us; but now the wind is turned to the south-west, you observe no such thing, because those effluvia are driven a contrary way.

The power which some bodies have of emitting these effluvia or steams, without being visibly diminished, is to me most amazing; yet that it is true we know by abundant experience. A single grain of musk will scent a thousand rooms, and send forth these odoriferous particles for a great number of years, without being spent. Surely these particles must be extremely small; yet their minuteness is nothing when compared with the particles of light, which pervade and find their way through glass, or to the magnetic effluvia, which passes freely through metallic bodies; whereas those effluvia that produce the sensation of smelling, notwithstanding their wonderful property of scenting all places into which they are brought, and without any sensible diminution, are yet too gross to pass the membranes of a bladder; and many of them will scarce find their way through a common white paper.

There are but few names to express the infinite number of scents that we meet with. I know of none but those of sweet, stinking, rank, musty, and sour; for so barren is our language in this respect, that the rest are expressed either by degrees of comparison, or from epithets borrowed from bodies that pro-

duce scent; which must, in many cases, be very inexpressive; for the smell of a rose, of a violet, and of musk, though all sweet, are as distinct as any scents whatever.

The next sense under our consideration is Taste, the organs of which are the tongue and the palate, but principally the tongue.——Ay, and a pretty organ it is, says Lady Caroline.—When used with your discretion, replied the Philospher. But I must observe to you, and the rest of the good company, that though bodies which emit light, sounds, and scents are seen, heard, and smelt at a distance, yet no bodies can produce taste without being immediately applied to that organ; for though the meat be placed at your mouth, you know not what taste it will produce till you have touched it with your tongue or palate.

Though there is an amazing variety of tastes, yet here, as in scents, we have but a few general names to express the whole; sweet, sour, bitter, harsh, smooth, and rank, are all that I can recollect; and our other ideas of taste are generally conveyed by borrowed similitudes and expressions as those of scents.——It is surprising, says the Ambassador, that in this age of gluttony, your language should be so barren as not to afford you words

to express those ideas which are excited by exquisite flavours.——Sir, says Mr. Setstar, this may be easily accounted for. I must inform you that we are indebted for our most expressive terms to the Poets, who were never much acquainted with good eating; and are less so since literature has lost its zest.——Very true, says Master Harry, their dishes, poor creatures, have lately been of the mental kind; but had you a few rich poets that could afford to live like people of taste, instead of your sweets and sours, and such old-fashioned terms, you would have the calapash and calapee flavour, the live lobster flavour, the whipt pig flavour, and a list of others as long as my arm.—Fie, Harry, says Mrs. Setstar, no more of that, I beg; you know Lady Caroline can't bear the name of barbarity.—Nor I, says the Ambassador; but pray what barbarity is there in this?—Oh! none at all, replied Harry, I only mean to insinuate that some of our great people are not content with having food brought from the East and West Indies, and every other part of the World, to gratify their palates, but they must roast lobsters alive, and whip young pigs to death to make them tender.—Good God! says the Ambassador, are there people in Christendom

capable of such acts of inhumanity? A man that would do that would murder me, if the law did not stand between us; and the law is but a poor screen where humanity is lost and conscience lulled to sleep. I'll apply to the King my master for my dismission, and no longer live with a people who have adopted such diabolical customs.——The Ambassador was so much in a passion, that it was with difficulty Mr. Setstar pacified him; and poor Lady Caroline, whose kind soul sympathises with every creature in distress, was in tears at the bare rehearsal of those acts of cruelty. Here Harry apologized to the company for having interrupted the Lecturer: perhaps he never before showed so much good sense; for he certainly deserved severe reprehension for introducing any subject which disturbed that harmony and attention from the hearers which had hitherto been preserved.

When silence was restored, our Philosopher arose and thus pursued his Lecture:——

I have already taken notice of four of our senses, and am now come to the fifth and last, I mean that of the Touch; which is a sense spread over the whole body, tho' it is more particularly the business of the hands and fingers; for by them the tangible qualities of bo-

dies are known, since we discover by the touch of the fingers, and sometimes indeed by the touch of other parts of the body, whether things are hard, soft, rough, smooth, wet, dry, &c. But the qualities which most affect this sense are heat and cold, and which, indeed, are the great engines of Nature; for by a due temperament of those two opposite qualities, most of her productions are formed.

What we call heat is occasioned by the agitation of the insensible parts of the body that produce in us that sensation; and when the parts of a body are violently agitated, we say, and indeed we feel, that body is hot; so that *that* which to our sensation is heat, in the object is nothing but motion.——Hey-day, says Lady Caroline, what sort of philosophy is this?——Why, Madam, says Master Harry, this is a position which has been laid down by these airy gentlemen for a long time, but which never has been proved by experiment.——Take care, says Mr. Setstar, or you'll forfeit all pretensions to philosophy.—The forfeiture is made already, says the philosopher; Harry has been bold enough to deny that which experience every day confirms for truth. If what we call heat is not motion, or occasioned by the motion of bodies, how

came Thomson's mill to take fire the other day, when it was running round without a proper supply of corn? And how came your father's post-chariot to fire while running down Break-neck-hill, Master Harry? Consider, there was nobody with a torch under the axle-tree; but this is a part of philosophy known even to the poor Indians, who, when hunting at a great distance from home, and wanting fire to dress their meat, take a bow and a string, and rub two pieces of wood together till they produce flame.——But you may see that heat is occasioned by the motion of bodies, by only rubbing this piece of smooth brass on the table—stay, I'll rub it: it must be done briskly. There, now, you'll feel it hot; but cease this motion for a time, and the brass will become cold again; whence we may infer, that as heat is nothing but the insensible particles of bodies put into motion, so cold, on the contrary, is occasioned by the cessation of the motion of those particles, or their being placed in a state of rest.

But bodies appear hot or cold in proportion to the temperament of that part of the human body to which they are applied; so that what seems hot to one, may not seem so to an-

Chariot fired by Motion.

other. This is so true, that the same body, felt by the two hands of the same man, may at the same instant of time appear warm to one hand and cold to the other, if with the one hand he has been rubbing any thing, while the other was kept in a state of rest; and for no other reason but because the motion of the insensible particles of that hand with which he has been rubbing, will be more brisk than the particles of the other which was at rest.

I have mentioned those objects which are peculiar to each of our senses; as light and colour to the sight; sound to the hearing; odours to the smell, &c. but there are two others common to all the senses, which deserve our notice, and these are Pleasure and Pain, which the senses may receive by their own peculiar objects: for we know that a proper portion of light is pleasing, but that too much offends the eye; some sounds delight, while others are disagreeable, and grate the ear; so heat, in a moderate degree, is very pleasant, yet that heat may be so increased as to give the most intolerable pain. But these things are too well known to be longer insisted on.

Now, from the ideas or conceptions formed in the mind by means of our senses, and the operations of the mind itself, are laid the foundation of the human understanding, the lowest degree of which is perception: and to conceive a right notion of this, we must distinguish the first objects of it, which are simple ideas, such as are represented by the words Red, Blue, Bitter, Sweet, &c. from the other objects of our senses; to which we may add the internal operations of our own minds, or the objects of reflection; such as are thinking, willing, &c. for all our ideas are first obtained by sensation and reflection. The mind, having gained a variety of simple ideas, by putting them together, forms what are called compounded or complex ideas; as those signified by the words, Man, Horse, Marygold, Windmill, &c.

The next operation of the mind (or of the understanding) in its progress to knowledge, is that of abstracting its ideas; for by abstraction they are made general; and a general idea is to be considered as separated from time and place, and lodged in the mind to represent any particular thing that is conformable to it.

Knowledge, which is the highest degree of the speculative faculties, consists in the perception of the truth of affirmative or negative propositions; and this perception is either immediate or mediate. When, by comparing two ideas together in the mind, we perceive their agreement or disagreement, as that black is not white; that the whole is bigger than a part; and that two and two are equal to four, &c. it is called Immediate Perception, or Intuitive Knowledge; and as the truth of these and the like propositions is so evident as to be known by a simple intuition of the ideas themselves, they are also called Self-evident Propositions.

Mediate perception is when the agreement or disagreement of two ideas is made known by the intervention of some other ideas. Thus: If it be affirmed that Tom Wilson's bay horse is as high as my father's, the agreement or disagreement may be seen by applying the same measure to both:——and this is called Demonstration, or Rational Knowledge. The dimensions of any two bodies which cannot be brought together may be thus known, by the same measure being applied to them both.

But the understanding is not confined to certain truth; it also judges of probability, which consists in the likely agreement or disagreement of ideas; and the assenting to any proposition as probable is called Opinion or Belief.——We have now finished this course of Lectures.——I hope not! says Lady Caroline with some emotion.——Why, returned the philosopher, we have taken a cursory view of natural bodies, and their causes and effects; which I have endeavoured to explain in such a manner as to be intelligible at least, if not entertaining; and pray, what more did you expect?——Sir, replied the Lady, I am greatly pleased with the account you have given us; and I thank you for the pains you have taken to answer the many questions I have troubled you with. What I had further to hope was, that you would have given us, when you was on the subject of Animals, some strictures on the cruelty with which they are too often treated; and have thrown in reflections and observations tending to enforce on mankind a different conduct. This I wished for, and should have been glad to have had Mr. Thomas and his Lady here at the same time; who are both extremely fond of their little domestic creatures; and I ad-

mire them for their tenderness and compassion.—These feelings and sentiments of the human heart, Madam, says the philosopher, add much to the dignity of our nature; and I am greatly delighted with such behaviour; but I am afraid, Lady Caroline, that we often mistake characters of this kind, and take that for humanity and tenderness which is only the effect of fancy or self-love. That Mr. Thomas has compassion, I grant you; but I am afraid it is only for himself. He loves his dogs and horses, because his dogs and horses give him pleasure; but to other creatures that afford him none, he is absolutely insensible. I have seen him, even at Christmas, feed his pretty pups, as he calls them, with delicacies; but rave at the same time in a merciless manner, at poor children who were shivering at his gate, and send them away empty-handed. Our neighbour, Mr. Williams, is also of the same disposition: he will not sell a horse that is declining, for fear he should fall into the hands of a master who might treat him with cruelty; but he is largely concerned in the slave-trade (which I think is carried on by none but we *good* christians, to the dishonour of our celestial Master) and makes no difficulty of separating the husband

from the wife, the parents from the children, and all of them from their native country, to be sold in a foreign market, like so many horses, and often to the most merciless of the human race. I remember him in great distress for his pointer Phillis, who had lost her puppies; but the same afternoon I saw him, without the least compunction of mind, force a poor man into the service of a new master, and tear him from his wife and children, for no other crime but because his skin was black. Is this humanity, Madam? Is this morality? But above all, is this christianity? And are these the blessed effects of the liberty we boast of? But do not let us be misled by specious pretences. We cannot judge of any man, Madam, by one single action, but by the tenor and result of all his actions; and this requires deep penetration, and an intimate knowledge of human life.

Benevolence, Lady Caroline, should be universal, for it is an emanation of the Supreme Being, whose mercy and goodness are extended to all his creatures, as ours also should be; for they are fellow-tenants with us of the globe we inhabit.

I have often thought that most of the mischiefs which embarress society, and render one contemptible to another, are owing to in-

ordinate ambition, or extreme love of power and wealth; for all the gold a man possesses, beyond that portion which is requisite for himself and family, only serves to inflame his ambition; as all the wine we drink, more than is necessary to recruit the drooping spirits, answers no other purpose but to intoxicate the mind.

I have seen a book in my papa's library, which gives some account of one Lycurgus, an old Grecian lawgiver; with whose character you ought to be acquainted. This man was of opinion, that religion, virtue, and good manners, were the only natural cements and preservation of liberty, peace, and friendship; which he found had been destroyed and extirpated by means of wealth and self-interest: he therefore prohibited the use of gold and silver, and all kinds of luxury in the state, and established such a plan for the education of youth of every denomination, as was most likely to confirm and habituate them in the practice of religion and virtue, and secure to the Spartans and their posterity the blessings of liberty and peace.

The event proved that his institutions were founded on sound policy, and a perfect knowledge of human nature; for in the space of

five hundred years, that is to say, from the time of Lycurgus to the introduction of wealth into the state by Lysander, in the reign of the first Agis, there was no mutiny among the people; every man submitted cheerfully to the laws of Lycurgus, and all were so united and powerful in consequence of their virtue, sobriety, and the martial discipline he had established (which was that of a national militia) that Sparta, a very small inconsiderable state, not only gave laws to the rest of Greece, but made even the Persian monarchs tremble, though masters of the richest and most extensive empire in the world. But when this great and virtuous people of Sparta had conquered Athens, and from thence introduced wealth and luxury into their own country, they lost their virtue, dwindled to nothing, and were themselves enslaved. Nor is this a matter of wonder; for where religion and virtue are set at a distance, and wealth leads the way to posts of honour and trust, some people will stick at nothing to obtain gold; but were dignities of this kind conferred on the most deserving, and none but men of virtue and superior abilities promoted to places of trust and power, there would be no frauds in the state, or violence among the people; and we might

then hope to enjoy the felicities of the Golden Age.

Man in that age no rule but reaſon knew,
And with a native bent did good purſue;
Unaw'd by puniſhment, and void of fear,
His words were ſimple, and his ſoul ſincere.
By no forc'd laws his paſſions were confin'd,
For Conſcience kept his heart, and calm'd his mind;
Peace o'er the world her bleſſed ſway maintain'd,
And e'en in deſarts ſmiling Plenty reign'd.

FINIS.

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